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PRIORITIES AND PROGRAMMES

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PREFACE

As part of its work on regional policy issues, the Regional and Country Studies Branch carries out policy-oriented studies and provides advisory services in key issues of industrial policy that affects groups of developing countries. These include issues of economic integration, issues in the relationship between technological change and industrial organization and policy issues in international cooperation for industrial development.

An important area of analysis is that of automation in industry. The spread of automation is having a profound impact on the manufacturing sector, both in terms of products and processes. It is associated with equally significant changes in the organization of industrial production. The effects of industrial automation in terms of costs and spread and flexibility, as well as in terms of reduced inputs of labour, are eroding cost advantages enjoyed by developing countries in traditionally labour intensive industries. In fact automation is associated with a general restructuring of world industry, and this finds expression in new and distributed forms of production.

UNIDO, in cooperation with the International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria, has carried out a detailed examination of the impact of industrial automation and how it is changing the production process. The analysis examined policies, both at the national and the company level to make recommendations on approaches to automation for consideration by developing countries. The work covers the whole field of industrial automation, but there has been a special concentration on the textiles, clothing and footwear sectors.

The present document continues the analysis to the level of international cooperation, by translating the trends identified into a set of requirements for support to developing countries in responding to these changes. In the first part of the document, an overview is made of the types of countries and branches that should be distinguished in designing such support. The second part of the document gives an outline of the kinds of technical cooperation programmes required, covering institution building,, direct support to manufacturing firms, and direct support to sectoral and public organizations. Financial support for the whole work has been provided by the Government of Finland.

The study has been carried out by the Regional and Country Studies Branch of UNIDO in cooperation with Dr. W. Haywood, Dr. P. Vuorinen and Dr. P. Spinadel, as UNIDO consultants.

CONTENTS

List of tables and boxes

PART I:

INDUSTRIAL AUTMATION PRIORITIES

AND DEVELOPING COUNTRIES

1. INTRODUCTION AND OUTLINE

Industrial automation is causing profound changes in the structure of world industry. For the developing countries, it represents a distinct challenge to traditional expectations as to how their industrialization might proceed. Without a correct response to the challenge of industrial automation, it is likely that developing countries will remain in their present weak and isolated position in terms of industrialization, removed from the centre of world manufacturing and remote from the benefits of growth and technological development. In so far as industrial growth continues to be a source of improved living standards and contributes to overall socioeconomic development, developing countries have a particular need to share in the benefits of world manufacturing.

World manufacturing is increasingly seen as a system. The growth of international trade, including intra-industry trade, and the spreading international character of foreign investment, together with the continuing increase in strategic alliances and mergers and acquisitions, mean that manufacturing activities take place across national boundaries and indeed across continental ones. The spread of information and the ready access to market intelligence (again fuelled by developments in microelectronics, including telecommunications) mean that manufacturing in developed countries and in the more advanced developing countries is a, increasingly, part of wider activity. Although it is now possible for the individual industrialist to see further beyond the factory gate so to speak and to reach wider markets for intermediate or final demand in other countries, and to make use of inputs of various parts of the world, the growing complexity of world manufacturing means that no individual manufacturer can see the full picture. The horizon has receded further.

A full examination of trends in industrial automation is contained in the forthcoming UNIDO study (Trends in Industrial Automation) which covers not only automation in general but also includes a particular consideration of the textile, clothing and footwear sectors and the receptivity of six African countries for industrial automation diffusion. It contains a full treatment of, in particular, four types of automation:

Computer-aided design and manufacturing (CAD/CAM)
Numerically controlled machine tools (NCMTs)
Robotics
Flexible manufacturing cells and systems (FMC/FMS)

Of these, CAD/CAM and NCMTs were identified, both in terms of their price and their flexibility, as being of particular relevance to all developing countries immediately. Robotics and FMS were, however, in view of their specialized nature and their less advanced operational stage, even in developed countries, of less immediate interest to developing countries.

The "systemic" nature of manufacturing that is the result of industrial automation was discussed above and is reviewed in detail in the study. The particular points to be made here about industrial automation as far as developing countries are concerned are that it goes in its effects far beyond the traditional expectation that it is a labour-saving technology. Certainly, industrial automation saves labour but it has many other effects which contribute even more to the competitiveness of the industry which adopts it:

- Improved quality and accuracy
- Quicker turn around times
- Greater products diversity
- Reduced skilled labour inputs
- Shorter lead times
- Shorter retooling times
- Minimization of raw material usage

Thus, although industrial automation is reducing the significance of cheap labour as a competitive strength of developing countries, it is, by allowing diversity and flexibility and experimentation with a wide number of different product lines, further weakening the competitiveness of developing countries that have traditional production lines whose adaptation to new forms of production in line with market requirements, fashion changes, is difficult, time consuming, and expensive. The significance of industrial automation for the competitiveness of developing countries and their industrialization prospects is therefore clearly established.

There is, however, considerable diversity among developing countries both in terms of their resource endowments, present industrial sectoral structure of production, and level of technological skills available within the country. For this reason, in considering the particular problems opposed to one country by world industrial automation trends, it is necessary to go beyond the general view of automation and its impact on particular industrial sectors, and relate it to the particular industrial structure within a developing country.

In the next section of this paper, there is an overview of the main socio-economic and institutional features of developing countries that relate to the absorbtion of industrial automation and its diffusion within the industrial structure. An initial typology of developing countries, looking at possible groupings of countries sharing common characteristics is presented. This examination is carried out in order to provide first indications of action in the field needed at the macro and institutional level. In the following section, there is a brief summary of the impact of industrial automation of the main industrial sectors. Section 4 then reviews the industrial structure of developing countries, and looks at the export orientation of industrial sectors in developing countries. It combines these views into an identification of the key sectors for industrial automation action in particular developing countries. The objective is to see sectors which countries are in most immediate need of action at the policy and enterprise levels in order to improve their competitiveness in international terms.

Part II of this document outlines the kinds of technical cooperation that could be provided for UNIDO activities in developing countries. It gives a detailed account of generic programmes of technical cooperation without specifying in detail the sector or country under consideration but concentrating on the types of physical inputs and requirements necessary in order to achieve signification action at the national policy, institutional or enterprise level, related to the automation of industrial production.

2. COUNTRY DEVELOPMENT AND INDUSTRIAL AUTOMATION

This section discusses different types of developing countries in the context of the different types of technical cooperation activities that may be envisaged to assist them in their industrial automation efforts. The projects outlined in Part II describe in some detail the kinds of technical cooperation activities that could be undertaken to encourage industrial automation. They are presented in generic form. This means that they do not at this stage specify a particular country, and in some cases do not specify a particular branch of industry to be the focus of action. Detailed examination of the individual country will be necessary in order to refine these generic project descriptions into a form suitable for direct application within the context of a particular countries developing program. However, developing countries, in spite of their diversity of geographical situation, resource imbalance and achievements to date, nevertheless share a number of common characteristics. These include, compared to the developed countries, low levels of integration of economic sectors, more fragile trade and investment links with the world economy as a whole, weaknesses in infrastructural and institutional developments, together with lower levels of technological capabilities. These are accompanied, usually, by inadequate or unformed policies and strategies to foster industrial development, including technology development at the level of individual firms. These have to contend very often with an unfavourable economic environment as well as particular difficulties due to the lack of supporting institutional assistance and the shortage of assured markets. Whether within the country or outside, there are often severe problems in the acquisition or development of technology, and a shortage of information on these processes.

For this reason some initial groupings of developing countries has been made in the context of the present study. The purpose of so doing is to highlight the different factors at work in determining technological development and the external assistance requirements in terms of industrial automation. By grouping countries according to economics and technological characteristics, it is possible to identify countries at similar levels and thus, if they are geographically close, regional cooperation possibilities may also be identified.

Any exercise in a grouping of countries, however, has to be strictly linked to a particular objective: countries belong to different groups depending what is the issue being studied. For the purpose of analyzing technical cooperation requirements and possibilities, five possible analyses may be considered:

(1) National Policies: This would be concerned with external assistance at the national policy level, whether in industrial policy or in connexion with trade, fiscal and administrative practices. The idea would be to assist not only in the formulation of the industrial policies that would encourage technological development and diffusion but also to provide support for the identification of obstacles to the realization of these policies. The practical steps necessary to implement and resolve into a series of measures that have to be considered in detail for their implications and their interrelations. Technical cooperation can provide important steps towards this end.

(2) Institutional Development: Here we are concerned with the creation at a national, regional or branch level of institutions that encourage and sustain the application of industrial automation to the manufacturing sector of the country concerned. It is at a broad field which would include R&D centres, demonstration centres, service centres, and advisory services. Institutional Report by providing a continuous store

of knowledge and expertise, a focal point for cooperative efforts, and a starting point for the creation of a wider network of public and private efforts in modernization expansion of industry.

(3) Industrial Branches: Assistance at the sectoral level will be concerned with the development of a particular industrial branch identified as a key component of general industrial strategy or as one where the problems and possibilities raised by industrial automation questions are particularly important. The sectors of textiles, clothing and footwear are ones which, in most developing countries, satisfies both of these criteria. However there are other industrial branches which are also particularly sensitive to automation questions. As far as technical cooperation is concerned, support at the branch level of industry would include a combination of measures. All of these studies and strategy development, institutional development, the provision of high level advisories services, restructuring and rehabilitation programs, and market development would be some of the possible areas in a branch level program of support.

(4) The Firm Level: A systems to an individual firm in connexion with automation suggests several specific steps. These would include analyses of the production process and automation systems development, advisory services, analyses of skilled requirements and the design and installation of appropriate information systems would be particularly important. When major restructuring and rehabilitation is involved, their will usually be a need also for assistance in the mobilization of external finance, thus the undertaking of feasibility studies and the promotion of investment will also be appropriate under this heading.

(5) Human Resource Development: This is not an easily separable subject, since human resource development will be an important consideration under one or other of the previous four categories discussed however, particularly at the national level, their is an important need for the assessment of human resources requirements for industrial automation and the devising of appropriate strategies to meet those needs. The scale requirements are not only in the maintenance and programming of automated equipment but also in the associated sectors such as the services, electronics, industrial design, and software development. These are critical fields for the success for implementation of automation on a wide scale. They constitute a human infrastructure essential to the growth and self sustained evolution and diffusion of automation techniques in the manufacturing sector. Thus, even though the operation of an automated machine as such may call for in fact lower skill levels and previously needed, the skill levels of the society as a whole to sustain the new strategy will be significantly high. For this reason the surveying of existing human institutional resources and the development of responses to automation needs in trading terms will be critical to the success of automation strategies. Given the present skewed distribution of automation capabilities between developed and developing countries, the technical assistance aspects will be particularly important. These will involve not only the traditional technical assistance activities of the supply of trainers and the holding of training courses but also the creation of new forms of relationships between automation practitioners in developed and the more advanced developed countries and those in other developing countries at initial stages of automation. The development of training strategies for industrial automation should pay particular attention to the isolation of developing countries in this regard: the potential users of automation techniques in developing countries are cut off from the

international automation community in which information on technologies, prices, and markets are exchanged widely and readily.

The above summary of the main headings for technical cooperation is not intended to replace the more detailed analyses contained in Part II of this document. It is intended only to indicate some considerations taken into account in the assessment of country groups that is now described.

National Policies for Industrial Automation

The types of support that are needed at the national level in the development and implementation of technology policies will be determined by a number of factors. Some countries will already have reached a high level of general economic development. This will mean in principle that some degree of manufacturing development has taken place, some supporting services are in existence, and some institutions are already in place.

Apart from general economic development, however, the particular achievements of the manufacturing sector are also another condition for deciding what kinds of international support would be needed. A further factor will be educational attainments, both in general and in particular with respect to higher level of training of scientists and technicians.

Finally it should be noted that the openness of a country to the outside world is an important condition for successful diffusion of automation techniques. Sometimes, restricted information flows limit the extent to which technology awareness can develop in a country. More generally, the availability of goods and the degree to which the country concerned is involved in international trade will affect awareness of products and of techniques. A strong export orientation will mean that the business community has frequent overseas contacts and may have a means of informing themselves on technological possibilities through regular visits to developed countries or to the other more advanced markets. Again, imports of manufactured goods also provide, in their own way, a means of information as to production possibilities. Thus the general "openness" of an economy may roughly be measured by the share of exports and imports combined as a proportion of GDP. For this reason, a number of developing countries have been grouped as to their national policy requirements according to their general level of economic development and technological capabilities. This has been done in the following way: a set of seven variables has been chosen that characterises the issues to be examined. These are as follows:

GDP per capita: This is a general measure of economic development which gives a first indication of economic progress.

Merchandise exports and imports as a share of GDP: This indicator gives the general "openness" of the economy as is described above.

Manufacturing exports and imports as a share of MVA: This gives a more precise indication with specific respect to the manufacturing sector.

Human Development: This is an index of general quality of life derived from UNDP's Human Development report. It measures a number of issues such as literacy, life expectancy, etc. and thus indicates to some extent the general stability, resilience, and flexibility of the society into which automation would be introduced.

Real GDP per capita is a measure of GDP per capita adjusted by purchasing power parities in order to reflect the real value of economic activity per head of the population. In some ways it is a more accurate indicator than is current GDP per capita already listed, but it is GDP in monetary terms which has an important affect on trade relations and investment potential, etc. and for this reason both indicators are retained.

Tertiary Science and Engineering: This measures the share of science and engineering students in total third level education and thus indicates the emphasis being placed on disciplines particularly relevant to the introduction and development of industrial automation.

Public Expenditure on Education: This is expressed as a share of total public expenditure and again gives an indication of the general level of emphasis being given to human resource development.

Manufacturing Share of GDP: This expresses manufacturing value added as a percentage of GDP and thus shows the importance of the manufacturing sector in the economy as a whole. In general such an indicator is, in fact, also an indicator of diversity within the manufacturing sector. When manufacturing is a small share of total economic activity, it tends to be combined only to a few sectors, such as food processing and perhaps the textiles and clothing. A large share of MVA and GDP, for instance about 20 per cent, would indicate a mature manufacturing sector which has a wide diversity of products and processes embodied in it.

Students Abroad: This indicator gives the percentage of third level students who are studying outside the country. In one sense this reflects, perhaps, the weakness of the domestic education sector but at the same time it is in the longer term positive as regards the knowledge and experience likely to be acquired by the students which will afterwards have an effect on the diffusion of technologies and the growth of industrial automation in the country concerned.

Table 1 shows the values of these nine indicators for a total of 56 developing countries and areas for which information was available.[1]

Using a statistical technique called cluster analysis, the countries and areas have been grouped into five groups.[2] This technique brings the countries together in two groups which are closely related to one another, in that the variables chosen are of similar size. Since countries are inevitably different in most aspects of their resource endowment and socio-economic characteristics, it must not be expected that they will fall neatly into five groups or seven or indeed anything other than 56 groups, since that is the number of

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[1] The sources for the data are as follows:

UNIDO (REG database) for current GDP per capita, trade openness, manufacturing trade openness, and MVA share of GDP. Remaining indicators are from the UNDP Human Development Report.

The units of the figures are as follows:

Current GDP per capita: 1989 US$
Trade openness, science and engineering share of tertiary education: per cent
The share of tertiary students abroad: per cent
Public expenditure in education per capita: US$ 1989
MVA share of GDP: per cent.

[2] Cluster analysis was applied using standardized variables, with the complete linkage method and Pearson correlation coefficients.

countries under consideration. Any grouping will always be a compromise, even though the cluster analysis technique will help in identifying the most rational groupings. The averages for the indicators for each of the groups are shown in Table 2 and the country composition of these groups is shown in Table 3. The shaded entries in Table 2 represent above average values.

Table 2 shows that group 1 has relatively low values of income per capita and of human development, as well as MVA share of GDP, real GDP per capita and science and engineering share of tertiary education. However, these countries have a high share of tertiary students abroad and a significant trade openness. They include some least developed countries but also some of higher income levels with more advanced industrial sectors, such as Algeria, Kenya and Tunisia. This group can be characterized as medium income, open.

Group 2 contains a large number of more advanced countries, mostly in Central or South America and also including one or two other countries with strong manufacturing sectors such as the Republic of Korea and Zimbabwe, However, this group has relatively closed economies both in terms of trade and also in terms of education. Policy action in this regard will be at least as important as institutional development and direct technical assistance in ensuring the diffusion of automation.

Group 3 contains a group of African least developed countries and also Nigeria. The economies are characterized by a low level of development and expenditure on education. Although openness is quite high, the income levels are such that autonomous processes of technology diffusion are unlikely of themselves to take place sufficiently quickly without direct external intervention.

Group 4 contains countries with above average incomes, including some oil producers in diverse regions. They are clearly above average in terms of income and in industrial development and have a high science and engineering concentration in tertiary education. Trade openness is at a low level and action in this regard will probably be at least as important as technical cooperation at the enterprise level.

It should be noted at this point that to proceed to more open strategies is a process that involves action in a number of fields. It is not only a question of reducing tariffs. It involves also questions in terms of the making available of foreign exchange, the reduction of administrative and procedural obstacles to trade, improvement of infrastructure, corresponding action in the field of the facilitation of inward and outward investment, and the like. No country can change from being closed to an open one over night. It is however an essential step if an individual country is to join the international manufacturing system.

Group 5, the last group, contains four countries and areas which are small in geographical area and which in fact vary widely in terms of income levels. From this point of view, the presence of Lesotho in the group is rather anomalous. This group has above average incomes both in current and real terms, together with very high degrees of trade openness and manufacturing trade openness. Education per capita is also above average, as is the share of tertiary students abroad.

Table 1. Indicators for policy and infrastructural development

	Current GDP/cap	Trade openness	Man.trade openness	Human devt.	Real GDP/cap	Sc.eng.share tertiary	Share tertiary stud.abroad	Public exp. educ/cap	MVA share of GDP
Algeria	2748.64	24.14	114.44	0.49	2470	14	0.6	6.1	11.35
Argentina	2592.5	15.15	40.18	0.854	4360	37	0.3	3.3	30.79
Bangladesh	170.49	22.11	252.63	0.186	720	34	0.8	1.3	7.43
Benin	387.83	35.38	498.92	0.114	1050	18	25.2	3.5	4.99
Bolivia	661.12	31.54	137.51	0.416	1480	21	1.8	2.9	13.43
Botswana	1348.85	151.51	648.77	0.524	2510	26	23.8	9.2	5.66
Brazil	2141.74	14.08	38.86	0.759	4620	40	0.5	3.4	27.33
Burkina Faso	204.04	17.22	105.35	0.081	650	21	30.2	2.4	12.93
Burundi	232.42	22.11	198.37	0.177	550	45	18.6	2.8	9.63
Central African Rep.	398.91	17.92	136.4	0.166	780	34	45.3	5.3	8.03
Chile	1510.99	47.86	154.29	0.878	4720	17	1.4	5	21.16
Colombia	1223.45	27.52	97.26	0.757	3810	36	1.3	2.8	19.92
Congo	1169.7	73.32	301.07	0.374	2120	8	28.3	5	7.82
Ecuador	1068.88	43.2	152.32	0.655	2810	21	0.6	4.2	18.70
Egypt	1230	33.5	186.57	0.394	1930	38	1.5	5.5	13.29
El Salvador	923.79	29	135.6	0.524	1950	50	1.9	1.9	17.48
Ethiopia	117.12	28.07	228.82	0.166	350	37	17	3.7	10.42
Gabon	3277.12	58.5	280.39	0.51	3960	22	26.2	4.8	8.14
Ghana	362.41	33.82	286.98	0.311	970	30	15.3	3.6	9.88
Guatemala	840.38	30.36	192.59	0.488	2430	39	1.9	1.8	12.42
Honduras	672.1	40.7	232.45	0.492	1490	29	3.7	5	13.04
Hong Kong	8427.44	167.02	695.64	0.934	14010	43	32.2	2.8	20.81
India	328.35	11.52	47.18	0.308	870	32	0.5	3.4	16.29
Indonesia	440.44	38.56	157.32	0.499	1820	39	1.6	2.3	16.97
Iran, Islamic Rep.	5827.11	6.02	27.56	0.577	3560	39	16.2	4.6	8.61
Iraq	2994.09	31.63	140.35	0.582	3510	33	3.3	3.7	7.99
Jamaica	1188.61	68.56	257.59	0.761	2630	37	21.5	5.6	22.31
Kenya	299.94	42.99	258.09	0.399	1010	21	17.3	6.1	12.19
Korea, Rep.	3170.94	66.93	204.83	0.884	5680	31	1.9	3	27.91
Lesotho	227.5	135.4	108.73	0.432	1390	16	10.7	3.8	9.73
Madagascar	167.47	38.95	314.11	0.371	670	20	11.5	3.5	10.23
Malawi	164.79	48.47	298.3	0.179	620	37	13.9	3.2	11.06
Malaysia	1913.88	96.33	292.48	0.802	5070	34	38.1	7.9	23.15
Mali	245.96	20.06	199.09	0.072	500	3	38.5	2.8	6.95
Mexico	1724.05	34.87	72.82	0.838	5320	36	0.6	2.8	25.76
Morocco	816	37.08	171.95	0.431	2380	59	13.9	5	14.72
Nicaragua	7507.24	3.92	15.56	0.612	2660	43	9.9	6.1	18.73
Niger	333.17	38.02	723.16	0.079	610	24	27.9	4	3.76
Nigeria	264.66	45.48	358.67	0.242	1030	30	6.8	1.4	4.32
Panama	2339.21	145.35	691.14	0.796	3790	32	3.4	5.4	8.29
Papua New Guinea	905.29	71.22	449.63	0.353	1960	11	5.7	5	10.18
Rwanda	329.52	16.17	103.55	0.213	730	25	37.7	3.2	14.59
Senegal	660.95	36.91	166.68	0.189	1250	31	23	4.6	15.78
Singapore	7751.8	311.3	924.54	0.879	10540	29	25.3	5	28.38
Somalia	235.07	29.21	433.24	0.118	1330	18	9.8	6	4.90
Sudan	529.07	12.86	96.27	0.164	970	27	27.3	4	8.07
Syrian Arab Rep.	2960.52	11.03	124.94	0.681	4440	31	8.8	2.9	6.63
Thailand	895.03	51.16	171.2	0.713	3280	25	0.9	3.2	23.98
Togo	397.27	60.49	621.22	0.225	700	52	26.2	6.5	6.47
Trinidad	3804.4	58.81	460.9	0.876	4580	43	61.7	5.8	9.17
Tunisia	1254.95	54.55	330.92	0.588	3170	31	24.5	5.4	13.03
UR Cameroon	1420.09	24.97	139.13	0.328	1670	35	40.3	3	11.04
UR Tanzania	146.8	40.34	716.92	0.266	570	9	31.4	1.7	4.13
Uruguay	2545.28	30.27	108.73	0.905	5790	48	0.6	6.6	21.85
Venezuela	2628.84	43.47	118.1	0.848	5650	26	1.1	4.3	22.81
Zimbabwe	622.08	49.06	52.83	0.413	1370	32	8.3	8.5	30.47

Table 2. Group indicators for policy and infrastructural development

	GROUP					
	1	2	3	4	5	*Overall*
Current GDP/cap	1215.94	1605.04	403.98	2515.32	4686.49	*1588.40*
Human development index	0.40	0.70	0.20	0.52	0.76	*0.48*
Share of tertiary students abroad	25.10	3.07	23.26	6.44	17.90	*15.26*
MVA share of GDP(percent)	9.04	22.18	9.97	13.32	16.80	*14.02*
Public exp.on ed.per cap	5.12	4.41	3.46	3.52	4.25	*4.23*
Real GDP per cap	2105.33	3662.67	845.38	2626.67	7432.50	*2694.29*
Sc.eng.share of tertiary	20.13	31.60	33.69	40.56	30.00	*30.34*
Trade openness	55.55	39.86	29.74	22.12	189.77	*49.57*
Manuf. Trade openness	401.48	135.04	225.57	110.34	605.01	*257.02*

Table 3. Groups of countries and areas

Group 1	Group 2	Group 3	Group 4	Group 5
Algeria	Argentina	Bangladesh	El Salvador	Hong Kong
Benin	Bolivia	Burkina Faso	Guatemala	Lesotho
Botswana	Brazil	Burundi	India	Panama
Congo	Chile	Central African Rep	Indonesia	Singapore
Gabon	Colombia	Ethiopia	Iran, Islamic R.	
Kenya	Ecuador	Ghana	Iraq	
Madagascar	Egypt	Malawi	Morocco	
Malaysia	Honduras	Nigeria	Nicaragua	
Mali	Jamaica	Rwanda	Syrian Arab R.	
Niger	Korea, Rep.	Senegal		
Papua New Guinea	Mexico	Sudan		
Somalia	Thailand	Togo		
Trinidad and Tobago	Uruguay			
Tunisia	Venezuela			
UR Tanzania	Zimbabwe			

3. INDUSTRIAL BRANCH PRIORITIES FOR AUTOMATION

Developing countries will face complex strategic choices and a correct response will have several components. It will include, as has been seen in the analyses of industrial policies carried out int the study Trends in Industrial Automation[3], action in the following areas:

Monetary and fiscal policy
Trade policy
Human Resources development
Investment policy
Institutional development
Infrastructural development

These are the main themes that characterise a comprehensive policy on the introduction and adaptation of technologies, and industrial automation policy will follow such an approach. However the question of sectoral or industrial branch emphasis needs also to be considered.

Given that the impact of industrial automation will be felt at a worldwide level and that it will affect all major trading industries, the question arises as to areas of concentration. The policy response of developing countries at a national and an enterprise level has to take into account the fact that they will not usually be in a position to undertake a simultaneous upgrading of all the manufacturing sector. Nor is it necessarily the case that all industrial branches in a developing country would have to be upgraded at the same time: some sectors may be too small and be unlikely, because of the nature of the products in question to face increased competition as a result of industrial automation in other countries.

In preparing programmes of technical cooperation the question of industrial branch emphasis will frequently be at the forefront. This is especially so if the cooperation is to be at the enterprise level and is to take place as a result of the initiative of a particular enterprise which has detected a pressing need for enhanced competitiveness due to increased competition as a result of growing industrial automation in the branch concerned. In other cases the cooperation may be suggested by a government as a result of concern with respect to a major branch, particularly if that branch is a relatively large one or one which is a major exporter.

An equally important consideration will however also be the fact that certain industrial branches, by their nature, are particularly sensitive to the impact of industrial automation. Because of the process involved at the branch level, there may be greater or lesser possibilities of introduction of industrial automation technologies. Again, industrial automation covers many different detailed technologies, and some industrial branches will see more importance attached to CAD/CAM, and others more to robotics, for instance.

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[3] "Trends in Industrial Automation", UNIDO, PPD.231(SPEC.), 12 October 1992.

This section of the report attempts an overview of the main possibilities for industrial automation in developing countries and thus the main target branches for programmes of technical cooperation. Although, as has been said, the initiative for a particular project may often mean that the target branch has already been identified, such an analysis is useful for several reasons. Firstly it indicates the kinds of issues that might be taken into consideration in appraising the proposed project, by looking at it in a wider context of evolution of branches at a world level. (This may also make easier the analysis of several projects when choices between them are rendered difficult and, as is usually the case, there are insufficient resources to cover them all.) Secondly such an overview may give some initial indications of directions and emphases in the formulation of country programmes and strategies. Thirdly, by providing a world view, there will be some indication of the dimensions of the problem, the kinds of countries and branches that are most often in question. This may contribute to the formulation of strategies on the part of donor governments and of programmes of technical cooperation by agencies, especially UNIDO. It can also point to areas of potential cooperation at the regional and sub-regional level, by showing the way in which neighbouring or otherwise related countries share common problems or have areas of potential cooperation.

The selection of priority branches for action could be based on a number of criteria. However, in view of the need for detail at the industrial branch level, attention has to focus on the kinds of statistical indicators that are actually available on a fairly comprehensive basis. The ISIC 3-digit classification divides the manufacturing sector into 28 industrial branches. This seems to be the minimum number needed to examine industrial priorities in the light of the impact of industrial automation. However, not all countries have data available at this level. A reasonably wide data coverage can only be achieved for the broader and more usual variables such as value added in the branch concerned.

The selection of branches has been made following four criteria:

Size: For this, among a number of possibilities, the share of the branch in total MVA has been used in considering the importance of the branch in question. Value added statistics are fairly available and usefully embodies wages and salaries as well as profits. The share in the total value added of the manufacturing sector indicates its significance for the countries industrialization efforts. The initial selection made includes those branches which have an above average ratio of value added to total MVA for the country. Thus what matters in the selection is which branches are important for the manufacturing sector, even though they may be small in world terms.

Export orientation: Because of the global nature of the industrial automation phenomenon and the way in which it is altering international patterns of trade, investment and location, it is particularly important, in deciding on industrial priorities at the national level, to see to what degree a country's industrial branch is actually involved in the international industrial system. This will indicate the sectors most likely to face increased competition from industries in other countries, and thus indicate the branches to which particular attention should be paid in industrialization modernization and technological upgrading, especially with respect to industrial automation. To measure this the simple measure of the ratio between the exports of a branch and its value added has been adopted. (Since trade and industrial production statistics usually come from different sources and use different classification systems

there is a measure of approximation in carrying out such an exercise, but, as will be seen the results are used in qualitative rather than quantitative form and are thus probably sufficiently accurate for this purpose.) Again the selection has been made on the basis of the branches in a country that have an above average export to value added ratio for that country, highlighting the branches that are particularly dependent on export earnings.

Table 4. Impact of automation by industrial branch

ISIC (3-digit)	BRANCH	CAD	NC Equipment	Robots	FMC	FMS	INDEX
311/2	Food	0	1	0	1	0	2
313	Beverages	0	1	0	1	0	2
314	Tobacco	0	1	0	1	0	2
321	Textiles	1	2	0	0	0	3
322	Clothing	2	2	1	1	0	6
323	Leather	2	2	1	1	0	6
324	Leather shoes	2	2	1	1	0	6
331	Wood products	2	2	1	2	1	8
332	Furniture	2	2	1	2	1	8
341	Paper	2	2	0	0	0	4
342	Printing	2	2	1	0	0	5
351	Ind. chemicals	0	1	1	0	0	2
352	Non-ind.chemicals	0	1	1	0	0	2
353	Petr. refineries	0	2	1	0	0	3
354	Misc.petr.products	0	2	1	0	0	3
355	Rubber	2	2	0	2	1	7
356	Plastics	2	2	0	2	1	7
361	China, etc.	2	1	0	0	0	3
362	Glass	2	1	1	2	1	7
369	Non-met.min.products	1	1	1	1	0	4
371	Iron/steel	1	1	1	0	0	3
372	Non-ferr.metal ind.	1	1	1	0	0	3
381	Metal products	2	2	1	2	1	8
382	Machinery	2	2	1	2	1	8
383	Elec. machinery	2	2	1	2	1	8
384	Transport equipment	2	2	2	2	1	9
385	Scientific euipment	2	2	1	2	1	8

Automation-sensitivity: the fact that different sectors are more likely to feel the impact of different kinds of industrial automation than others has already been referred to. The basic data for this analysis is derived from Table 4, which provides an index of sensitivity to industrial automation for each of the 28 industrial branches of the 3-digit ISIC code. Again the branches with above average values for this index were selected as being of greater priority, because these would feel the first effects of stronger competition as a result of the improvements as a result of automation. It should be noted however that all the branches that have an above average value for this index also have an above average value (i.e. a value of 2) for the impact of CAD/CAM and of numerically-controlled machinery. These two types of automation have already been identified as the types most immediately relevant to developing countries, because of their low cost, their flexibility for different kinds of applications, and the fairly mature state that the technologies have attained.

Table 5 presents the results of this analysis. It shows the main branch priorities for individual developing countries as a result of applying the criteria described above. The table is to be read as follows. The rows are the developing countries and areas for which suitable data was available. The columns are the three-digit ISIC industrial branches. An entry of 1 means that the branch in the country in question has an above average (for the country) ratio of exports to value added. An entry of 2 means that the branch makes an above average contribution to total manufacturing value added in that country. An entry of 3 means that both these criteria are fulfilled and that the branch is not only an important part of the industrial sector but also a significant export earner. In the table the shaded columns refer to those sectors with an expected above average automation impact.

The data in the table show that there is not a complete convergence between automation and overall industrial priorities, in that most of the branches that are important from the point of view of their contribution to value added or as exporters are not those in which the impact of automation is expected to be most immediately significant. For instance, treating a branch as a priority one **either** if it has an above average share of value added **or** if it has an above average export/value added ratio, the branch with the most number of points would be ISIC 311/312 Food Processing. This far exceeds the total for any other industrial branch. And yet this branch is not one in which automation can be expected to make as considerable an impact as in other branches.

Table 6 summarises the results of this analysis in terms of industrial branches, showing the frequency with which branches are particularly important to developing countries either because of export orientation or because of their large share of manufacturing value added. From this point of view, food processing (ISIC 311/2) is the most important branch, as might be expected. The next most economically important industrial branch is textiles, with a score of 76. However, this is another branch which has below average significance in terms of the impact of automation, although it is materially linked to the clothing sector, which certainly is, and is the most important of these economically important branches to be significantly impacted by automation. (In Table 6 the shaded branches represent those for which the impact of automation is above average, i.e. for which the index number in Table 4 is 6 or more.) The other main group of branches in the engineering industries, where significant automation impact is expected, also have important economic significance for developing countries as is seen in the quite high scores achieved for instance for metal products, machinery, and electrical machinery and transport equipment.

Table 5. Indicators of automation priorities by branch

	311	313	314	321	322	323	324	331	332	341	342	351	352	353
Algeria	2		2	2	2					2		1		1
Argentina	3	2		2		1						2	2	2
Bangladesh	3		2	3	1	1						2	2	2
Benin	3	2		3	2		2		2				2	
Bolivia	3	2		1		1		1				1	2	2
Brazil	3			2		1	1					2	2	2
Burkina Faso	3	2		2	1	1		1					1	
Burundi	3	2	2											
Cape Verde	3		2		2						2			
Cent.Afr.Rep	3	2	2					2			2		2	
Chile	3	2		2						2		1	2	2
China	3		2	3	1	1			1			2		2
Colombia	3	2		2	1	1				2		2	2	1
Congo	2	2	2	2			2	3	2				2	1
Costa Rica	3	2			1	1					2		2	2
Cuba	3	2	2							1		1	2	
Cyprus	2	2	2	2	3	1	3	2	2		2		1	1
C^te d'Ivoir	3	2	2	2				2					2	2
Dominican R.	2	2	2	2	1	1							2	2
Ecuador	3	2		2						2			2	1
Egypt	2			3	1	1			1				2	1
El Salvador	3	2	2	2			1	1		2			2	2
Ethiopia	3	2	2	2	1	1							2	2
Fiji	3	2			3		1	2	2	1	2		2	
Gabon	3	2	2					3				1		2
Gambia, The	3	2		2		1			2		2			
Ghana	3	2	2	2				2					2	2
Gustemala	3	2		2					1				2	
Guyana	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Honduras	3	2	2					2				1	2	2
India	3			3	1	1	1					2	2	3
Indonesia	3		2	2	1	1		3	1	1		2	2	2
Iran,Isl.Rep	3		2	3									2	2
Iraq	2			2		1						3	2	3
Jamaica	2	2	2		1				2		2	3	1	2
Jordan	2	2	2	1		1						1	3	2
Kenya	3	2		2		1				2		1	2	1
Kuwait	2				2									3
Libyan Ar.J.	2	2	2				2					3		3
Madagascar	3	2		2		1				2			2	2
Malawi	3	2	2	3							2	2	2	
Malaysia	3		2	2	1	1	1	2				2		1
Mali	3		2	2	2	1	1	1		1		1	1	
Malta	2	2			3	1			2		2			
Mauritius	2	2		2	3									

1=High Exp/VA; 2=High MVA share; 3=Both; High automation impact shaded

Table 5. (continued)

	354	355	356	361	362	369	371	372	381	382	383	384	385	390
Algeria	1					2	2		2		2	2		
Argentina			1				3	1	2	1	2	2		
Bangladesh													1	
Benin						2			2					
Bolivia								3		1		1		
Brazil							3	1	2	2	2	3		
Burkina Faso								1	1	1	1	1		3
Burundi									2		1			
Cape Verde												2		
Cent.Afr.Rep												2		2
Chile				1			2	3				1		
China	1			1		2	2			2	2	3	1	1
Colombia						2	3				2	2		
Congo									2		2	3		
Costa Rica		1	2		1		1				3			1
Cuba							1					2		
Cyprus					1	2			2	1	1	1		
C"te d'Ivoir			1						2	1		2		
Dominican R.				1		2	1	1	2		1		1	1
Ecuador			2			2			2	1	2			
Egypt						2	1	3	2	2	2	2		1
El Salvador			2		1	2		1			1			
Ethiopia											1			
Fiji						2			2			2		
Gabon						2			2	1	2	2		
Gambia, The														2
Ghana								3		1				
Guatemala		2				2	2	1						1
Guyana	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Honduras			2			2			2	1		1	1	1
India						2	2			2	2	2		1
Indonesia							2					2	1	1
Iran,Isl.Rep						2	2	1		2				
Iraq						2				3	2		1	1
Jamaica												2		1
Jordan		1	1		1	2			2	1	1	1		2
Kenya		2					1		2		2	2	1	
Kuwait					1	2			2			1		
Libyan Ar.J.		1	1			2				1	1			
Madagascar														
Malawi						2								
Malaysia		2				2		1		1	3		1	1
Mali		1	1	1	1				2	1	1	2		
Malta		2							2	1	3	2	3	2
Mauritius					1								1	

1=High Exp/VA; 2=High MVA share; 3=Both; High automation impact shaded

Table 5. (continued)

	311	313	314	321	322	323	324	331	332	341	342	351	352	353
Mexico	3	2		2						1		3	2	2
Morocco	3	2		2	1	1	1					3	2	
Nepal	3	2	2	3	3	1							2	
Nicaragua	3	2	2	2								1	2	2
Niger	2	2		2	2						2		2	
Nigeria	3	2		2		1						1	2	3
Pakistan	2		2	3	1	1	1					2	2	2
Panama	2	2	2	1	2	1				2	2	1	2	2
Papua New Gu	3	2	2	1				2						
Paraguay	3	2		2	1	3	2	2			2	1	1	2
Peru	3	2		3	1								2	3
Philippines	3	2	2	2	3	1	1	1	1			1	2	2
Qatar	2				2						2	2	1	3
Rep.of Korea	2		2	2	3	1	1					2	2	
Rwanda	3	2	2					2				2		
Senegal	3	2	2	2								3	1	2
Singapore	1			1	1	1		1			2	2	2	1
Somalia	3	2	2	2		1			2				2	
Sri Lanka	3	2	2	2	3								2	2
Sudan	3		2	2	1	1						1	2	1
Syrian AR	2		2	2	1				2			1	2	3
Thailand	3	2	2	2	3	1	1					1		2
Togo	3	2		2	1		2			1		1		
Trinidad	2	2	2			1				2	2	1		3
Tunisia	3	2		2	3	1						1	2	1
Turkey	3		2	3	1		1					2	2	2
UAE	2	2		1	1	1				1	2	2	2	1
UR Cameroon	3	2		2		1		2					2	1
UR Tanzania	3	2	2	2							2			
Uruguay	3	2	2	3	1	3	1		1	2		1	2	2
Venezuela	2	2	2	2								2	2	3
Yemen	3	2	3	2										
Zaire	3	2	2	2			2					2	1	
Zambia	2	2	2	2								2	2	
Zimbabwe	3	2	2	2	2	1					2	2	2	

Table 5. (continued)

	354	355	356	361	362	369	371	372	381	382	383	384	385	390
Mexico			1		1	1	3	1		1	1	3	1	
Morocco						2		1	2		2			1
Nepal						2								
Nicaragua					1		1		2	1		1	1	1
Niger						2			2					
Nigeria				1		2			2	1		2	1	
Pakistan						2	2						1	1
Panama		1	2	1		2		1		1	1	1	1	1
Papua New Gu									2					
Paraguay						2	1			1	1		1	
Peru								1			2			1
Philippines			1					1		1	3		1	1
Qatar			1			2	3		2					
Rep.of Korea							2		2	3	3	3	1	1
Rwanda						2			2					
Senegal						2			2	1	1			
Singapore			1	1	1			1	2	3	2	2		1
Somalia								1						1
Sri Lanka		2	1			2				1		1	1	1
Sudan							1	2	2	1		1		1
Syrian AR						2			2			1		
Thailand			1			2		1		1	1		1	3
Togo						3	1		1					
Trinidad						2			2			2		
Tunisia						2	2		2	1	1		1	
Turkey			1			2	3			3	2	2	1	1
UAE		1	2	1	1	2	1	3	2	1	1	1	1	1
UR Cameroon			2				2	1		1	1	1		
UR Tanzania		2						1	2			2		
Uruguay							1					2	1	1
Venezuela							2	3	2					
Yemen						2			2					
Zaire												2		2
Zambia						2	1	1	2			2		
Zimbabwe					1	2	3	1	2			2		

Table 6. Importance of industrial branches

ISIC	Branch	Index
311	Food	135
313	Beverages	59
314	Tobacco	48
321	Textiles	76
322	Clothing	53
323	Leather products	43
324	Leather shoes	21
331	Wood products	22
332	Furniture	15
341	Paper	18
342	Printing	19
351	Ind chemicals	54
352	Non-ind chemicals	62
353	Petr refineries	63
354	Misc petrol.products	3
355	Rubber	13
356	Plastics	20
361	China, etc	9
362	Glass	13
369	Non-metallic minerals	45
371	Iron/steel	39
372	Non-ferrous	34
381	Metal products	41
382	Machinery	41
383	Elec. machery	43
384	Transport equipment	48
385	Scientific	26
390	Miscellaneous	35

Table 7 amounts to a selection of first priorities at the country and industrial branch level. It is derived from Table 5, where the economic significance of industrial branches was described in terms of basic indicators with the value 3 representing a branch which was both important in terms of its share in value added and also in terms of the ratio of exports to value added. Table 7 shows only those countries where a value of 3 was found and where this was in a sector where the impact of automation would in general be above average.

Table 7. Selected countries and branches for priority action

	Clothing	Leather Products	Leather Footwear	Wood Prooducts	Machinery	Elect. Machinery	Transport Equip.	Scient. Instr.	OTAL
Brazil							■		1
China							■		1
Costa Rica						■			1
Cyprus	■		■						2
Fiji	■								1
Gabon				■					1
Indonesia				■					1
Iraq					■				1
Malaysia						■			1
Malta	■					■		■	3
Mauritius	■								1
Mexico							■		1
Nepal	■								1
Paraguay		■							1
Philippines	■					■			2
Rep.of Korea	■				■	■	■		4
Singapore					■				1
Sri Lanka	■								1
Thailand	■								1
Tunisia	■								1
Turkey					■				1
Uruguay		■							1
TOTAL	10	2	1	2	4	5	4	1	29

The selected countries for priority action are those where a first analysis of the data such as is described indicates that particular importance would seem to be attached to improving a specific branch's automation capabilities, the branch being both economically significant in the country and also one in which world markets and thus international competitiveness could be significantly affected by the impact of industrial automation technologies. The countries in Table 7 are not usually least developed countries, with the exception of Nepal; they include a wide variety of middle income developing countries and NICs. Five of the countries are in Latin America and the rest in Asia or in developing Europe. With respect to industrial branch priorities, clothing emerges as clearly the most important with this being a priority in no fewer than ten of the 22 countries. The next most significant industrial branch which has a priority is electrical machinery with non-electrical machinery and transport equipment following.

4. CONCLUSION

The above analyses have attempted to identify countries in which the general levels of economic development and the socio-economic and educational infrastructure are appropriate to different kinds of policy and institutional action, in order to ensure the diffusion of automation technology in a manner appropriate to the kind of progress likely to be achieved autonomously. An open industrial sector with active links to the outside world, and an educational system with a relatively high degree of public spending, a concentration on science and engineering subjects and a good contact with educational systems in other parts of the world, are more likely to lead to some degree of automation diffusion than a closed economy with little attention paid to these educational priorities. In the latter type of country, the need for international cooperation and support, especially in the development of appropriate institutional infrastructure for advisory services and for human resource developments will be very great. It must be accompanied, however, by a careful attention to the policy variables which may be inhibiting the autonomous diffusion of technology at the enterprise level.

In this area, there are many other variables that should, ideally be taken into consideration, and the variables selected for the initial country grouping are intended to give a broad indication of the kinds of issues at stake in the determination of the appropriate policy response. They are not intended as a substitute for detailed analysis at the stage of country programming and project formulation. At this stage, other variables must also be considered to give more detail on the specific role of technology and the degree of international integration of the manufacturing sectors of the country concerned. The level of physical infrastructure, especially telecommunications, the degree of availability of industrial information and commercial intelligence, the practical difficulties in administrative procedures, such as the time taken to obtain clearances, licences, authorizations, etc., will all have a bearing on the kinds of policy response needed. If the indications are that the response will be, for instance, the development of a specific industrial branch related to technology institution, than the shape this will take will be very much determined by the organization of the industrial branch concerned, especially in terms of the size distribution of enterprises, the location of enterprises, and the presence and suitability of existing institutions to be adapted or redirected towards the specific needs identified.

Part II of this document contains outlines of a number of actions in the field of technical cooperation for the adjustment absorption and development of automation technologies within the manufacturing sector, including action at the national, industrial branch and enterprise level. In adapting these outlines to the specific needs of individual countries, the above considerations should be incorporated through specific analyses in the country concerned.

PART II:

GENERIC PROGRAMMES OF TECHNICAL COOPERATION

PROGRAMME 1: INSTITUTION BUILDING

An essential activity will be assisting countries in establishing/strengthening permanent national organizations in automation-related fields. Working institutional infrastructures are among the principal conditions for successfully modernizing manufacturing technologies. To implement advanced automation technologies such as NCMTs, CAD, Robotics and FMS there are various basic infrastructural needs in training, education, research, and policy guidance to support techno-economic development, and functioning institutions have an important role in meeting these needs.

In the following, the needs of infrastructural institutions for automation related development are addressed from the point of view of international assistance in establishing and strengthening permanent national organizations.

1.1 ESTABLISHMENT/STRENGTHENING OF EDUCATIONAL/TRAINING INSTITUTIONS

To implement and use automation successfully, manufacturing companies need:

- skilled workers for running, controlling, maintaining and repairing the automated equipment;
- specialists able to install, troubleshoot and programme the equipment;
- managers able to organize and manage the introduction and use of automated machinery as well as support the personnel in the process of change;
- a reliable system to upgrade personnel skills.

These can be supplied by many organizational arrangements. Nevertheless, a good and comprehensive national educational infrastructure with corresponding institutions is an essential condition also for other arrangements to succeed. The system should include:

- basic (primary) education;
- secondary education giving:
  - sufficient knowledge and skills to enable attendance at universities and other institutions of higher education; and
  - vocational education furnishing practical skills for various jobs;
- higher education to produce technical and managerial skills;
- a flexible system for further (adult) education.

The last item on the list, further education, has the most flexibility in organizational form. It can be arranged partly as firm/sector specific training, and partly as general further education organized on occupational/skills basis. Even vocational education can be organized either as a national institutional system or in cooperation with firms, for instance on an apprenticeship basis.

The most industrialized developing countries, e.g. the East Asian NICs, have for a long time given much attention to creating good educational infrastructures. This is reflected in their technological performance, both at the production process and the product development level.

Nevertheless, in a large majority of developing countries these systems are not working adequately, and various supportive measures are needed. In least developed countries, the problems go back to insufficient systems of basic education. With respect to UNIDO, however, the focus is on vocational and other educational institutions more directly relevant to technological development and especially automated production technologies. Generally, vocational education is the most severe bottleneck of educational systems in developing countries: at the secondary level, the proportion of vocational versus liberal enrolment is 10:90 while the relation in developed countries is usually 50:50.[4] It seems that the crucial role of vocational skills in manufacturing development has been widely neglected. Instead the focus has been on basic employment and on exploiting the comparative advantages of abundant and cheap labour supply.

Not all problems need (permanent) institutional arrangements for their solution. Again, institutional solutions may not be possible or realistic because of the situation in the country/region. In these cases, direct educational/training support measures - training courses, training visits, seminars, meetings, and support to firm internal training etc. may be more feasible.

Supportive measures strengthening educational institutions could be many, depending on the development level of the country and the targets to be reached. A first task in any case is, however, to evaluate the ability of the existing educational/training system to meet the needs set by automation related development in manufacturing.

1.1.1 Evaluation of the existing educational system

From the point of view of skill needs for developing production technologies, the basic questions that have to be answered before any automation related development project on educational institutions is started include:

- How well does the national educational and training system meet the needs of further industrial automation?

- How can it answer to the present and future needs on
  - skilled, vocationally educated workforce (by sector/occupation, and both on basic skills and in upgrading the skills on line with future technological development)?
  - various types of automation (and computer etc.) specialists?
  - (automation) management personnel?

A survey on these topics is needed whenever more comprehensive programmes for updating production technologies are introduced in a country, or production technology upgrading is generally taken as a development target in the country.

The scope of the study can vary from a relatively simple survey based on statistical studies and interviews with industrialists and policy makers to a more comprehensive one including a curricula analysis and a productivity (the skills produced) analysis of the existing institutions. Studies can be done on an institutional, country, or even regional basis.

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[4] A. Salam & A. Kidwai: A Blueprint for Science and Technology in the Developing World, Technology in Society 13; 4, 1991.

An analysis of the educational systems' performance must also be done even in the case of a minor - company level - automation project, in order to evaluate the labour supply and skills upgrading abilities of the education/training system. In this case, however, the measures to overcome the problems usually do not go back to the institutional level, but to temporary training or firm level training measures.

Resources needed:

From one specialist for 3 - 4 months (a general one-country study based on statistics and local interviews or a more comprehensive study of the performance of one institution) to a one year project with more specialists (curricula and performance analysis, or a more superficial regional level study).

The output of the analysis will be detailed knowledge on the performance of the educational system and on the institutional development needs related to the appropriate skills for automation technologies.

1.1.2 Establishing a new educational institute

Establishing a new institution for industrial automation/advanced production technologies may be a requirement when the need is clearly defined in the country (or the region). However, a new institution should only come into consideration when the need is continuous, and the demand is high enough (and, in principle, growing). In addition, a new institution is relevant only if an existing institution cannot be used to meet the educational requirements in question.

In many cases it is more sensible to establish an educational institute that can support industrial firms in other respects as well. These other roles of the institute could include for instance the supply of (technological) business services, acting as an information provider or technological advisory centre, or even as a supplier for research and development services for individual firms.

The whole planning and establishment of the institution could be carried out by international organizations. This kind of a "turn key" project, is expensive, and it only comes into question in a country where the local resources are very modest.

Even if an institution is to be established as a "turn key" transfer of technology, execution of the project should be done in close cooperation with the local parties involved (industrial companies, local authorities, the staff of the future institute etc).

It is not desirable to start a new educational institution based only on a foreign/international initiative. The initiative, motivation and interest must come from inside the country (or region). In the case of an institution for education/training in advanced automation technologies it may often be more reasonable to establish a new institution based on regional cooperation arising from regionally expressed needs. This would share the burden, would help to reduce the need for resources outside the region and would also ensure that the facilities were fully utilized.

Depending on the type of institution and the country, international aid might include the following:

Feasibility study on the proposed institution

This might include themes such as those mentioned above in 1.1.1, but on a more detailed level, e.g. including the economic feasibility and continuous running costs of the institution. The study should, above all, answer questions such as the following:

- what need is the institution to meet?
- how well does it answer - both in the short run and in the long run - the need faced?
- could the problem be better resolved by some other solution?
- what are the benefits and costs of (establishing and running) the institution?
- what seem to be the major problems in establishing the institution, and what are the likely main problems in operating it?
- to what extent are domestic resources sufficient in implementing/running the institution?
- what kind of aid is needed from international organizations:
  - in the establishment phase,
  - in long-term operation?

A feasibility study is a basic step to be taken in any instance of new institution establishment, and international experience of corresponding institutions elsewhere could give much extra help to the first planning phase in overcoming initial problems.

Assigning experts to assist the local authorities in planning and establishing the institution

Different types of experts may be needed, depending on the local capabilities. The specialists may include economists (for the estimation of running costs of the institution, economics of the institution from the point of view of local production structure and firms), teachers and trainers in various fields to assist in planning the relevant areas, experts in curricula planning etc. Even assistance in physical building issues may be necessary.

In the case of a vocational institute for automation related training, it is especially important to employ reliable experts in evaluating the needs for machinery to be installed in the institution. It is important that the machinery

- represents up-to-date technology;
- is relevant to - and to some extent compatible with - the present/near future technology used in domestic companies;
- can be (gradually) renewed without extremely high new investments when it becomes technologically obsolete;
- is equipped by the supplier with effective spare part and repair service, as well as software and technical assistance;
- would have high utilization rate (is useful for many purposes).

Choosing the right equipment is of foremost importance, both for cost reasons and because of the skills to be learned by using it.

Seminars on experiences from similar institutions

Experience from both developed and developing countries should be compared. All groups and persons relevant to the establishment of the new institution - and running it

in the future - should participate in the seminars. Seminars such as these are necessary in all cases where new institutions are under serious consideration. They are especially important in cases when the planning and establishment of the new institution is being mainly carried out with domestic resources.

In the example case of a vocational training institute for industrial automation, the series could consist of three principal seminars:

- The first seminar should be before or during the feasibility study phase, where the problem and possible solutions are discussed. On this occasion, the main focus is on comparing experiences from various countries and collecting the basic information on the needs. There should be prepared presentations from:
  - experts from developed countries evaluating their experiences;
  - experts from other developing countries where similar institutions exist;
  - domestic education experts describing the situation of the education system, and the role of the new institution in the system;
  - domestic industrialists explaining their skill needs to be met by the future institute.

  The target group of this seminar comprises local decision makers (in industrial and education policies), industrialists and the potential funders of the project.

- The second seminar should take place after the feasibility study phase, with a focus on discussing the issues relevant in planning and establishing the institution. There should be prepared presentations from:
  - bodies responsible for the feasibility study;
  - local industrialists and decision makers;
  - foreign experts (both in education and educational planning) with experience of planning institutions resembling the one in question;
  - equipment suppliers and technology experts;
  - funders of the project, foreign and domestic.

  The target group comprises all bodies relevant in establishing the institution. It may be useful to arrange various thematic seminars in the planning phase, concentrating on various issues in the planning process.

- The third seminar should take place before (or when) the institution is inaugurated. This time the focus should be on explaining the future activities of the institution and, especially, in creating and strengthening cooperative activities between the institution and other local organizations. There should be presentations by:
  - the management of the new institution;
  - teachers and other professional staff of the institute;
  - representatives of local industry;
  - representatives of other industry (training etc.);
  - institutions the new institutions is expected to/hoping to cooperate with.

The seminar should be targeted to all interest groups relevant to the new institution. In this seminar, the role of foreign experts should be minimized: the principal aim is to create a dynamic interactive development process between the training institute and local economy. However, foreign experts presenting examples of various types of local cooperation between training institutes and local economy, and telling their experiences of cooperation on local level might nevertheless be useful.

Building and equipping the institution

In the case of a vocational training institute for industrial automation, the need for foreign resources may be high. The less experience the country has in automation training and automated production, the higher it will be. In addition to basic aid in actual planning and carrying out the building activities, foreign aid is typically important in furnishing the institution with machinery and equipment.

In a typical vocational training institute for industrial automation, the equipment costs are high. And, again, it is important that the technology chosen be up-to-date, in line with the technologies present in the country and that it can be modernized flexibly without too high investment costs. In this respect, it might be useful to cooperate with equipment suppliers - usually from developed countries - on e.g. leasing basis. Relatively close links to equipment supplie.s are also essential in securing spare parts supply and technical/software assistance.

In terms of equipment, a typical case of a vocational training institute for industrial automation might include some or even all of the following types of equipment, depending on the scale of the institute and the needs of industry:

- Computers
- CAD systems
- NCMTs
- Associated networking equipment
- FMC
- FMS
- Robotics equipment

In addition to this, there will be requirements for standard and advanced equipment for instruction needs, including:

- Audiovisual equipment
- Computer-assisted learning (CAL) equipment

Finally there will be requirements in terms of:

- Office equipment
- Office and classroom furniture

1.1.3 Strengthening existing training/educational institutions

More typical, and usually more effective than establishing a new training/education institute, is to strengthen the existing institutions in automation-related training/education.

In many cases even establishing a new institution actually takes the form of strengthening an old organization. It is more usual, and more practical as well, to build a new institute - in the sample case a vocational training institute in industrial automation - as a new department of an old institute rather than as a completely new establishment. There are synergetic effects both in terms of physical infrastructure and in terms of carrying out the daily teaching activities.

The areas of assistance could include:

Curriculum planning

To plan curricula to match the needs of automation instruction often needs aid from developed country institutions. The resource needs again vary, depending on the previous national experience on manufacturing automation and automation training. In a country with some previous automation experience, it is usually enough to get experts to evaluate the plans and give advice on details.

The less local experience in automation exists, the more extensive curricula planning expertise is needed. Particularly useful is to utilize all available experience there is from comparable institutions in countries culturally near to the country in question.

Teacher training

Teacher/trainer training is an important field of assistance to educational institutions. Training to update knowledge is needed continuously, even in countries with relatively extensive automation experience. Aid to teacher training may take many forms:

(a) Support to sending teachers abroad to study for a period:

The length of training may vary depending on the start up level of teacher trainees. In a case where teachers have experience in industrial vocational training, but no automation expertise, a period of one term automation training abroad might be sufficient. If teacher trainees have no experience at all on modern, computerized technologies, longer basic education to the subject may be necessary. Again, the less previous experience there is, the longer is the training abroad that is needed.

Even for teachers with automation expertise it is useful to arrange shorter courses abroad to update developments in recent technological and organizational automation innovations.

In many cases, international development cooperation creating regular systems for teacher training abroad can make an essential contribution to strengthening developing country training/education institutes.

(b) Employing experts to help in planning and establishing basic/further teacher/trainer training in industrial automation:

If no previous teacher training in automation exists in the country, the expertise needs are extensive and relatively lengthy. The target should be to start domestic teacher training with basically domestic human resources within a few

years. It is, however, quite likely that in this kind of situation some foreign aid in supervising teacher training is needed for a rather long time.

Arrangements in which the upgrading of domestic teacher training with foreign expert help and the regular sending of trainees abroad are combined can be fertile and result in a dynamic process of capability growth within a developing country training institute.

(c) Arranging seminars for teachers on the latest developments in manufacturing technologies, with foreign (from equipment suppliers, manufacturers employing the relevant technologies, researchers on new trends in technology developments) and domestic experts (to provide analyses of local needs and possibilities for developments):

This type of seminar is very necessary for the staff in all automation-related educational institutions, since the technology is advancing very rapidly.

If there are more ambitious plans to gear a country's development path more towards using automated production technologies, this type of seminars are absolutely indispensable. Even skilled and capable teachers need continuous updating of information and skills in new automation equipment, applications, software and organizational solutions.

(d) Other forms of updating teachers skills and knowledge include exchanges of staff between training institutions (teachers) and local industrial firms (supervisors, technical managers):

Through such arrangements, teachers can update their understanding of the problems and actual changes in the workplace, and company supervisors/technical managers can bring the practical knowledge and approaches to the training institution, in addition to brushing up their own basic technological skills.

These objectives can, however, be met fully only in countries where industrial automation is relatively widespread, and considerably developed manufacturing companies exist. In countries with more modest automation diffusion and less developed companies, on the other hand, teachers can act as technology/knowledge diffusion agents and update the company's manufacturing practices while working in the company. And the supervisors/technical managers update their own knowledge on technologies in the training institute.

A simpler from of knowledge diffusion is through visits: teachers can make familiarizing visits to private enterprises (local, national and foreign), and company supervisors/technical managers and visit the education/training institute.

(e) A useful way to induce continuity into upgrading teacher skills is to create long standing cooperation relationships with a developed country training institute:

Cooperation with a counterpart institute could include regular staff exchange and frequent interchange of both planning information and substance knowledge.

The role of the counterpart institute in the developed country could also be extended to more comprehensive responsibility for various issues of strengthening the institute in a developing country.

International aid organizations can act as catalysts through establishing the links between possible cooperation partners in developed and developing countries and aiding in organizing finance for the efforts.

Aid in strategic planning

Developing country training institutes need support not only in training teachers, but also in other issues of renewing their activities. An important and frequent direction for extending the activities of a training/education institution is to expand its cooperation with other local organizations. In doing this, international aid agencies could arrange consultative help to the institute in renewing its operations.

Forms of aid supporting the expansion of activities and supporting local cooperation could include:

Arranging cooperative seminars between educational/training institutions and industrial/other relevant local institutions. The seminars should have two main targets: intensifying local cooperation between the institution and local firms and organizations as well as updating the training institutions knowledge on the real skill needs - and trends - in the local business.

Another form of intensifying local cooperation is the planning of new activities for the institution. These could include supplying business services (computer services, consultancy in manufacturing technology development, maintenance & repair services, marketing & financial services etc.) or even small-scale manufacturing of e.g. spare parts to meet the needs of local firms.

In practice, this means a relatively radical change in a training/education institution's activity profile. In redirecting the activities and planning how to carry out the new ones, foreign expertise is often of great importance, both in terms of finance and capabilities. However, it may be nonetheless quite fruitful to develop a local educational institution in the direction of a technology centre.

Supplying new equipment

This is a typical field of activity for which international assistance is necessary. The issues discussed with respect to machinery when discussing establishing a new institute for vocational training in automation are relevant also in supplying old institutions with new equipment.

A critical aspect to take into account in acquiring new equipment is that it be compatible with the old machinery. This helps in accumulating knowledge and skills, while, conversely, a complete change to new types of machinery often also results in growing needs of new trainer/teachers skills, and many previous investments in skills and capabilities are lost.

Creation of information channels

Supporting the training institute to create regular channels to reach the main reach the main sources of up-to-date information is one of the basic tasks in strengthening a educational/training institution. This includes connections to databanks and a sufficient supply of relevant publications. Aid could consist of:

- Linking the institute to the main databanks in their field of activity. This must often be accompanied by support to the computerization - or modernization of the computer systems - programme of the institute. International aid could also include financial support to the running costs of databank connections.

- Supplying the institute with a continuous flow of the most important periodicals, magazines, journals and research publication series in their field of activity.

1.2 ESTABLISHMENT/STRENGTHENING OF TECHNOLOGY CENTRES

In developed countries, various types of technology centres have become an extremely popular instrument to diffuse and develop technology. The scope, or ambition of a technology centre may vary from a rather modest establishment aiding local enterprises in limited technology problems - e.g. a CAD centre - to extensive institutions of Science Park scale. A common feature of all technology centres is that their basic activities are targeted towards diffusing technological innovations and advancing cooperation between local economic agents. Experiences from technology centres in developed countries have so far been quite positive, especially from the point of view of local small- and medium-sized firms.

The activities of a centre are often overlapping with educational/training centres. A typical technology centre - if we leave Science/Research parks outside of discussion - is a local "competency centre", that is serving the local economic environment in technological information, some business services and various types of further training. In some cases, the centre is also used for basic vocational training. Typical functions of a technology centre include:

- **vocational education:** the premises, equipment and other resources including the personnel can be used by institutions of vocational education for their basic training courses;

- **further training / adult education:** the centres typically provide training courses in technological skills to personnel of local firms and other organizations. Even courses open to all interested may be offered;

- **information diffusion:** centres act as agents of technological information diffusion in many forms. Typical activities in this field are seminars, lectures and exhibitions on various topics; providing equipment for individuals/firms to familiarize themselves with new technologies; and providing published material for those interested on matters relevant for the centre. A technology centre may even prepare information material on technological developments for training and other purposes;

- **providing technological services**: the centres often provide technological services to local firms provided that their equipment is suitable. This activity, carried out on a commercial basis, is targeted especially to small- and medium-sized companies that have relatively limited and such infrequent needs that continuous subcontracting relations with commercial firms would be uneconomic. The most usual form of technological service supply is the design of computer software applications adapted to local conditions.

- **acting as a networking agent**: a further typical activity of many technology centres is acting as a mediator and linkage creator between local firms and outside organizations. The linkages may concern e.g. linkages in production services, research and development, acquiring new manufacturing technologies or finding subcontractors to provide parts to local companies. Technology centres do also, of course, act also as networking agents within the local industrial community through e.g. establishing linkages between local companies and other organizations.

- **acting as a research and development** organization: in some cases, technology centres also carry out some - often relatively modest - research and development activities, either at the behest of local firms or in connection with their own educational/development needs. This is typical for technology centres with a focus on software issues. It is, however, more typical that a local technology centre helps a local company in defining the research/development need, and then helps the company in finding a suitable organization - usually from outside the region - to carry out the task.

The types of technologies can vary, as can the functional emphasis. A centre can be established only for training purposes, or only/mainly for providing production services, or for a combination of all functions mentioned above. A modest technology centre is often only a training institute with a few additional service-producing and networking functions.

Centres with all the functions combined are typical e.g. in Sweden, where they have usually been established as cooperative efforts between local enterprises, equipment vendors, municipal governments, labour unions and regional educational institutions, often with central governmental financial support. In the Swedish case, the main focus - in terms of technology and function - of the institution varies a lot depending on the structure and needs of the regional economy.

1.2.1 Establishing a CAD/CAM centre

In developing countries, the most typical technology centres are CAD (or CAD/CAM) centres with emphasis on rather limited areas. Institutions of this type have been established in various environments at different development levels, and UNIDO has also prepared detailed guidelines on planning a CAD/CAM centre, with the main focus on CAD training and designing CAD software applications (with interface to NCMTs) suitable to local conditions.[5]

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[5] "Planning and programming the introduction of CAD/CAM systems - A reference guide for developing countries", UNIDO, General Studies Series, ID/SER.O/1, January 1990.

There are some basic issues especially important in a developing country context to be taken into consideration, when thinking about establishing CAD/CAM centre as a development project:

- The centre must become a genuine institution for technology diffusion that is available to a large audience needing information, training and advice. There is always the danger that the establishment only becomes a further institution for prestige education, with relatively few practical implications on the economy. This is to be feared especially if training is mainly trained for high level management personnel: the main focus should usually be in basic vocational training to use the equipment.

- In many developing countries, basic training in computer literacy for a wide variety of trainees is an important dimension of activities, even if the main focus would be on teaching very specific computer applications.

- Cooperation with equipment vendors is especially important for both hard- and software supply, basic training, maintenance and future expansion and modernization of the equipment. However, dependency on the vendor should not be so high, that the qualifications supplied are useful only in context with a single vendor's equipment.

- The activities of the institution must be focused in line with the present and immediate future needs of local enterprises. intensive cooperation with local organizations is also extremely important.

The establishment procedures, equipment needs and costs of a CAD or CAD/CAM centre are explicated in the UNIDO document "UNIDO Guidelines for Project design of CAD/CAM centres in developing countries".

However, establishing a centre to support more demanding CIM applications is a more complicated task and also clearly more expensive. For example, setting up a tooling centre with robotics, NCMT and FMS equipment might only come into question in a relatively developed and industrialized country with an important car industry, for instance.

In establishing any kind of new technology centre, it is necessary to start with a feasibility study monitoring the needs for and the main focuses of the institution. In doing this, many procedures described in section 1.1 are practical here as well. In establishing cooperation with local actors, seminar series and other, perhaps more informal types of information spreading methods are also useful.

1.2.2 Strengthening existing technology centres

CAD(/CAM) centres existing in developing countries are as a rule quite new, and they may not yet need much upgrading and modernizing. However, there are many other types of organizations supporting industrial development in developing countries that could be strengthened more towards the direction of technology centres. For example, more technology development and support functions could be combined with more conventional sectoral organizations, such as training centres or even service institution/departments of industrial associations.

In the usual case, this means acquiring new technology equipment to the institution and redirecting the activities towards technology support direction. Adding technical support, advice and training on CAD to a sectoral organization is a typical way of starting up. For example, expanding a textiles and clothing training centre in the direction of technology support is a natural way to develop. In practice, this means a need to acquire CAD equipment and other technologies required for the centre and to plan the new activities.

In doing this, the procedure of establishing a CAD or CAD/CAM centre should be followed. However, the first task is to evaluate the activities of the organizations, whether it is an industrial association or a sectoral training organization, and relate it to the changing needs within the sector:

- Is it more justified to expand the activities of the institute, or to establish a wholly new organization?
- How much would the whole profile of the organization have to be changed with the renewal?
- What would be the contents and focus of new activities, and the costs of them?
- Where is foreign support needed?

This kind of feasibility study on changing/expanding the institution's activity profile should also be done when initiating a change to establishing new departments. It is quite often more effective to strengthen and renew old institutions than to establish new ones, especially from the point of view of start-up costs and needs for new infrastructure.

Crucial issues in strengthening an institution as a technology centre are:

- providing the centre with enough expertise on planning, setting up and - in the initial phase - running the new functions;
- upgrading the qualifications of personnel to perform the new tasks;
- choosing and acquiring new equipment for the centre.

International assistance in expanding an industrial centre towards becoming a technology centre can broadly be planned along the same lines as in the case of establishing a new institution. Aid to personnel upgrading can take forms similar to training the personnel of a training/educational institution: training abroad, exchange of personnel, foreign experts to carry out courses on automation technologies etc.

As in the case of an educational institution, it might be very useful to set up close cooperative relations with a similar institute in a developed country. The partner institute could help the centre on a regular, long range basis by diffusing information and through continuous further training of personnel. The main role of a development assistance agency would be the creation of the linkage between the institutions and perhaps supplying the basis financing for the cooperation.

Information linkages, allowing access to up-to-date information, are crucial to all technology centres. In order to ensure this, international aid programmes strengthening technology centres should also monitor the institutes' linkages to the major databanks in

the field. In addition, they should ensure that the centre has a good, continuous supply of relevant research publication series, magazines and business journals in their field of activity. If needed, foreign aid should be allocated to supplying these.

1.3 ESTABLISHMENT/STRENGHTENING OF RESEARCH INSTITUTES

In the long run, technological development also requires support from institutionalized research and development. This is especially true for creating new technology based products, but even a wider diffusion of advanced production technologies needs backing from domestic research. The implementation of automation is connected to a wide variety of problems to which there are no "on the shelf" solutions. In addition, adapting new production processes and products to each other in a new environment and further development of locally appropriate automation solutions also needs research and development support.

Aid to establish or strengthen research institutions in developing countries to support the applications of automation related technologies can take quite similar forms to those of aid to educational institutions and technology centres. The first issue is again to evaluate the need for a new institution and/or the need to expand the activities of existing institutions. What are the problems addressed with the new institute? Is there enough demand for the work done in it, and is the demand likely to grow? What should be the main focus of the institute, and what are the basic targets?

The most important areas of institutionalized research from the point of view of promoting automation and other advanced production technologies are various fields of technical research, e.g. research on mechanical and electric engineering, mechatronics, and other direct technological studies on automation technologies.

The target of a technical research institute is to produce information for the basic understanding and development of the technologies for actual use. Research also produces the highly skilled engineering specialists who are capable to aid companies in technical problems and training technical personnel. Research and development institutions should, in a developing country context, also be able to help other organizations in solving their technical problems. In this respect, activities of a technical research centre in a developing country often come close to those of a technology centre.

There is also a pressing need in developing countries to strengthen research on organizational and economic consequences of automation, as well as on technology policy options. These fields include investigating the skills needs, training and education requirements, and the economic and organizational as well as business strategy effects. This kind of research is necessary to evaluate the effects and consequences of further technological development. The basic studies may be carried out with foreign resources, but in the long run domestic research to support decision making is indispensable. This type of research is not discussed further in this context, while the focus is on technical research supporting automation implementation in industrial firms.

When planning to establish a new technological research institute, a regionally operating organization is often more likely to be able to gather enough resources and operate more effectively than a national institute, especially when we are not dealing with the most developed developing countries. Founding a new research institute is a

demanding task, and should be taken as an alternative only when a long term need is undeniably identified.

Strengthening research institutions may only consist of providing the personnel in a local technological research institute with training in automation-related matters, or giving consultancy aid in restructuring the activities of the institute. Often it also includes assistance in supplying the institute with new equipment needed in research and development. However, the most urgent needs are - in addition to straightforward financial aid - in the field of information linkages: developing country research institutes need regular channels for up-to-date scientific knowledge.

The different assistance possibilities may include:

- Giving consultancy aid in restructuring the activities of the institute;
- Giving assistance in studying organizational and economic consequences of the introduction of new automation technologies in the local industrial society;
- Giving direct financial assistance;
- Establishing or strengthening information linkages;
- Establishing or strengthening cooperation with other research institutes in developing/developed countries.

1.3.1 Restructuring the activities of the institute

This project could be seen as a whole, but in most cases only some of the activities would be necessary. The complete programme should include at least the following steps:

Studying the actual organization and available resources of the institute and determining the position of the ongoing research work inside the international research

This could be done through the assistance of one expert for at least three weeks, and not more than two months, to prepare a report on the actual situation with some proposals for a new structure and clear definitions of the level of research in the different areas. The work could include:

- Visiting the different laboratories to determine the existing resources, how they are being used and what for;
- Individual discussions with researchers to build up a picture of the internal functioning of the institute and detect possible structural problems;
- Individual discussions with people from industry and government to assess the degree of integration of the research centre in the country's industrial system.

Assessment of requirements of local industry for selection of new research areas or modification of existing areas

This could be done through the assistance of one expert for at least one month, and not more than three months. On the basis of the report prepared in the first step, some working-meeting should be arranged with representative of sectoral institutions and from leading companies to discuss their requirements. The consultant should also assist in the selection of possible research fields, determining in which cases it would make sense to carry it out locally, in which cases a joint venture with a developed country research centre

would be helpful, and in which cases a direct contact between the industry and a developed country research institution would be appropriate.

Support for entry into a new research field
(determination, selection of equipment, medium and long term planning, etc.)

Depending on the field, this should be done with assistance of one or more experts, for a period that could range from a couple of months to a couple of years. In some cases the assistance could be realized through the strengthening and/or training of personnel in selected research areas.

Assistance in training for a better (optimal) use of the existing equipment

For selected areas and based on the above assessments, the institution could be helped in the organization of seminars and training courses.

Selection and supply of new equipment needed in research and development, and training in its use

Depending on the research area this could be done with the assistance of one expert for a period ranging between one week and two months. The assistance could include a seminar with presentation of possible equipment by representatives of the supplying companies.

1.3.2 Study of organizational and economic consequences of the introduction of new automation technologies in the local manufacturing industry

The assistance should include two components:

- A **seminar** on automation and its effects on organizational and economic structures. The first part of the assistance project will be the holding of an initiating seminar on the effects of the introduction of new automation technologies. The main lines of the seminar programme could be the following:

  - **Target group/participants:** representatives from companies, local researchers on the sector and representatives of governmental bodies responsible for the sector.
  - **Duration:** Three days.
  - **Programme:**
    - **First day:** Prepared presentations by donor agencies, researchers and industrialists from both developed countries, and developing countries that have more experience on the introduction of new automation technologies. Discussion relating the social problems in the country's industry to the experience abroad.
    - **Second day:** Presentations by the local industrialist and governmental representatives about the social problem they have found in the past by the introduction of other technologies. Visits to local companies.
    - **Third day:** Team work to produce outlines about the necessary studies to be done.

- **Consultant** services to assist the organization in the formulation of studies to be carried out in the local industry. This could be done with the help of one international expert for at least one month and not more than six months.

1.3.3 Establishing or strengthening information linkages

Some forms of strengthening developing country research institutes to reach the important information sources include:

- Assistance in linking the research institute with the main data banks in their field of activity. This must often be accompanied by an overall computerization, or a modernization of the computer systems of the institute. International aid could also include financial support to the running costs of data bank connections.
- Strengthening other telecommunication contacts between the institute and developed countries institutions, e.g. through acquiring telefax ore electronic mail equipment for the institute. This is, however, dependent on the degree to which the national telecommunication system is adequate for the task.
- Supplying the institute with a continuous flow of the most important periodicals, magazines, journals and research publication series in their field of activity.
- Supporting the establishment of a national/regional productivity data base centre.
- Supporting the establishment of a technology data base centre.
- Supporting the institute in the international publication of research work.

These issues - telecommunication linkages abroad, supply of published information and links to data banks - are among the basic conditions for any research institute to function effectively today. Their status should be checked and defects remedied as a first task in any support programme aiming to strengthen a research institute.

1.3.4 Establishing or strengthening cooperation with other research institutes in developing/developed countries

For a technological research institute in a developing country, regular contacts with corresponding developed countries institutes are absolutely indispensable. They serve both as a regular channel to transfer scientific information, and as a means of upgrading the skills of researchers. A fruitful form of international development aid to strengthen a research and development institute in a developing country could consist of creating, supporting and financing constant cooperation between the institute in question and a developed country research institute. The cooperation programme could include:

- Sending on average perhaps three researchers each year to the developed country institute to work in research programmes relevant to the developing country. The length of work in the institute may vary depending on the type of research done, but it should not be less than a year.
- Organizing shorter working visits (ca. one to three months) for five to ten other researchers to the developed country institute. The visits should be related to acute problems the researchers are working with, and not remain just familiarizing visits.

- Sending on average three researchers to the developing country institute from the developed country institute, to work in local development projects previously determined as cooperative research areas.
- Arranging shorter term expert visits from the developed country institute to the developing country institute, to assist especially in supervising and solving critical problems in local research and development projects.
- Arranging cooperative seminars on technical themes of current interest between the two institutes.

If the institutes are connected - or in close collaboration - with (technical) universities, the cooperation should be expanded to cover doctoral courses. This might include sending five to ten doctoral students each year to the developed country institute. Their dissertation work should be on topics relevant to domestic technological development projects. On the other hand, the exchange programme between two institutes should include encouragement and support for developed country doctoral students to work on research problems related to the needs of the developing country partner.

1.4 ESTABLISHMENT/STRENGTHENING OF INSTITUTIONS FOR PRODUCTION SERVICES

Difficulties with production services and logistics are among the main problems faced by developing country manufacturing firms. For more automated production, defects in these could become fatal. Supportive basic production services, logistical infrastructure and networks of supporting companies are of high importance. The important production services from the point of view of automated production include a sufficient presence of subcontracting firms to produce intermediates, reliable and swift provision of spare parts, repair and maintenance to machinery, computer services including support to software development and - to a growing extent - support to product development, marking and market research.

This section concentrates on production services ensuring the smooth running of the actual manufacturing process: maintenance services, computer services and other technical services.

Production services can be organized through public institutions, as private companies within the business community, or as joint efforts between local firms and/or between firms and other organizations. Support to vital production services might consist of e.g. establishing new institutions or strengthening the existing ones.

If the local business community is not strong enough to support private firms producing e.g. spare parts, repair and maintenance services, it might be worthwhile to establish an institution supported through publics (aid donor) funds to supply the services. However, it is usually more effective to launch the services not through an independent organization, but as a part of an educational/training institute of a technology centre.[6] Such multi-function institutes are usually more dynamic and effective; their various functions support each other and they can become central institutions fort the industry

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[6] Subcontracting exchanges, in practice concentrating on the mechanical engineering sector and related fields, have been established by UNIDO in several countries and subregions. They are typically located in a Chamber of Commerce or Industries.

within the region. Establishment/strengthening such an institution may well follow the lines of support to a technology - e.g. CAD/CAM - centre.

Basic spare parts, for example, could well be supplied as a business activity of the local vocational training institute. This activity would also assist the training institute in creating linkages to the everyday activities of local industrial firms. More demanding repair, maintenance and software issues fit usually better to the activity profile of a technology centre. International aid could be allocated to establish these activities in the relevant local institutions.

1.5 ESTABLISHMENT/STRENGTHENING OF OTHER INFRASTRUCTURE INSTITUTIONS

Basic physical infrastructures - reliable power supply, transport facilities including roads and equipment, telephone connections etc. - are necessary for all industrial development. In the case of automation and other advanced production technologies, provision of stable electricity supply and telecommunication networks becomes highly important. Renewing - e.g. digitalizing - the telecommunications network is clearly the most directly automation and high technology related factor, while the other issues can be seen more as basic national infrastructure building. However, when planning an automation project, the stable supply of electricity is crucial, and it must be secured either by national systems or through plant specific arrangements.

Detailed discussion on aid to build up basic infrastructure is outside the scope of this paper. In the following, the main options for international assistance in supporting institution building in the field of basic infrastructures from the automation point of view is briefly highlighted:

- Development of the national systems for electricity production and distribution. Fluctuations in electricity supply can be fatal for advanced production technology. If local electricity networks are not good enough, the building up of a specific network may come into question. This is, however, a very expensive and extensive task that should be considered only as a highly exceptional solution. In special cases, a plant specific electricity supply network may also come into question. Nevertheless, in most cases, a reserve system of electricity supply for emergency situations and to smoothen out the fluctuations in network supply is needed on the firm/plant/local level.

- Establishment and modernization of telecommunication networks is another basic infrastructure task. Industrial firms employing modern automation need modern telecommunication networks both within the plant, between individual plants within the company, in linkages to their local/domestic partners and especially in their connections abroad.

- Modernizing the basic transport infrastructure, including transport infrastructure, air, sea, road and railroad connections, depending on the type of industrial activity and the location of the firm sites. In the case of road transport, it is not only a question of reasonable road and traffic conditions, but also of networks for fuel distribution, and car/truck maintenance services.

Forms of support may vary, depending on the current state of infrastructure and the available national resources. They may range from straightforward financial assistance to the actual building up of the systems as complete aid projects:

- Direct financial aid to responsible national organizations;
- Expert advice for the organizations in planning the modernization projects;
- International aid in execution of the infrastructure establishing and modernization projects;
- Turnkey establishment of the whole new infrastructure system by external donors.

1.6 STRENGTHENING OF GOVERNMENT INSTITUTIONS

In this context government institutions refers to policy-making institutions, not infrastructure-related public systems. Experience from developing countries with rapid industrial growth shows that governmental policies can have a critical role in creating new comparative advantages and in directing the economies to a more technologically lead development path. Policies for automation are one issue in a wider set of infrastructure, industrial and technology policies.

Technology policy seems to be a relatively weak policy sphere in many developing countries. For example in many African countries, technology is generally not considered as a major issue for industrial development. One consequence of this is that technological change is often seen more as a threat to employment and economic development in the country and technology policy is more restrictive and negative than supporting and expanding. Even in cases where explicit technology policies have been outlined, they often remain poorly integrated with other policy spheres: they are often unrealistic, formal and not related to the actual economic and industrial situation in the respective country.

Thus, the need for international assistance in strengthening technology policy institutions in policy planning is often urgent. The assistance can take various forms:

1.6.1 Information on technological development for policy makers

Information spreading can be arranged through e.g. seminars, meetings and conferences. A sample of a seminar on developments in manufacturing technologies to a developing country policy makers could consist of the themes below. The contents of a seminar or series of seminars should depend on the development level of the country in question and on the industrial sector that is taken under discussion as a possible target for further automation related development:

- "Possibilities of modern production technologies": A case example from a developed country.

- "Ways of using similar technologies in a developing country": enterprise-level case studies from countries comparable to the country in question.

- "Where are the limitations and possibilities?": the views of local companies on the problems, possibilities and hazards related to the technology in discussion.

- "Technology and economic development": researchers' views on the necessities of introducing/possibilities of avoiding the use of the relevant technology and the effects and preconditions of further automation diffusion. The themes to be taken under scrutiny could include, depending on the country and themes then of present most concern:
  - productivity growth and competitiveness;
  - production technology development and employment;
  - skills, education and training in developing technology;

- technology, organizational development and business strategies;
- the global competitive situation in the sector and the possibilities for response;
- the limitations of labour cost competitiveness;
- the need for high quality, modern design and other specific issues related to using production technologies;
- infrastructure development and advanced production technology;
- technology policies to support production technology upgrading;

- "Policy options to support technological development": A policy makers opinion (from a developed country, or from a developing country with more experience on technology policy and automated manufacture than the country in question).

- Panel discussion including the discussants, local industrialists and policy makers.

The target of the (series of) seminar(s) should be a raising of the level of policy makers' awareness on advanced production technologies. It could be arranged as a starting up occasion for launching national technology policy on automation issues. In doing this, as in all technology policies development, it is important that policy makers are in a continuous and expanding interaction with representatives of the local economy. This can ensure that the policy will have a realistic background, and the measures undertaken will be relevant from the private enterprises' point of view.

A series of similar seminars could be arranged in many developing countries - preferably within the same area - with the aim of both spreading information, and of collecting comparative information on the situation of technology policy planning in the respective countries. The series should be completed with a larger conference including participants from all the countries involved.

A crucial aspect such of seminar work is the close interaction and exchange of opinions between:

- industrialists with experience of technology development problems;
- policy makers responsible for technology policy development;
- developed country specialists/industrialists/policy makers able to compare the problems in the light of longer experience.

The target should not be a seminar publication or a general declaration, but a concrete activity problem, starting from a defining the main problems and bottlenecks in the country's technological development, and ending with concrete, time scheduled and allocated activity programme. The programme should not include only general policy options, but also very concrete development projects, pilot and test cases to carry out institutionalized technological development. International aid organizations could support the activity programme by supporting it financially and supplying the explicit development programmes expertise.

Visits to developed country firms, research and technology policy institutions are another form of activity that can be used as media to spreading information to national policy makers and raise their consciousness level on automation and technology policies issues. In combination with seminars and more straightforward training courses they could

be relatively effective means for increasing the policy makers knowledge and awareness of technology policy and automation issues.

1.6.2 Support for technology policy institutions

Technology policy institutions can be strengthened by supplying them with direct expertise. Experts could be focused on the process of planning new technology policy options, or they could concentrate more on renewing the activity structures of the policy institution.

1.6.3 Interaction between governmental policy makers and private enterprises

This is crucial for launching effective technology policies. Support for the creation of successful channels for interaction and cooperation between policy makers and firms is a major task where international aid might help. In addition to the methods mentioned above - seminars and company visits - regular meetings and consultative procedures between the parties should be instituted.

An important aspect is that the forum created for interaction should be informal enough to encourage free discussion between the parties. International organizations could help - in addition to financial aid - in supporting the local parties with expertise on team working and discussion methods, to help in creating a forum for free discussion.

1.6.4 Technology development finance centres

These are typical technology policy organs in developed countries. Their main task is to grant financial aid to technology development projects. In addition to financial arrangements (direct subsidies, loans with lower interest rates or various forms of risk financing) this usually includes the evaluation of the proposed project, supervision in executing it and establishing linkages between firms/organizations that could support each other in their development projects.

The most advanced of developing countries have corresponding institutions, and the establishment of such might well be an effective way to allocate financial support to technology development projects in various developing countries. It is often practical to establish an institution that is not directly a department of any governmental ministry, to give it more freedom in activity and a more independent public image.

1.7 ESTABLISHMENT/STRENGTHENING OF TECHNOLOGY INFORMATION ORGANIZATIONS

The diffusion of information on technology options is an essential task, often necessarily accompanied by support for firms in technology selection. Governmental and other public institutions are not the only ones working in the field of spreading information on new technologies. Industrial and employer associations, chambers of commerce and other local business organizations can have an important role to play in supporting technological development. And in some cases international aid may be more effective if it is allocated to this kind of organization rather than to governmental bodies.

Support to a local chamber of commerce, an industrial association or corresponding institution in extending its activities to spreading information on new technologies and

assisting companies in technology selection can take many forms similar to aiding technology centres and other public institutions. The assistance can be allocated to establishing a new type of activity or to strengthening an existing activity, by e.g. improving the personnel's skills in the field or giving direct assistance in the form of finance or expertise. The possible fields and forms of aid to this type of organizations:

- The institution can act as a networking agent between local firms and foreign technology suppliers, research institutes and industrial associations (chambers of commerce etc.). To strengthen this activity, a donor organization can help the institution in choosing and creating the linkages to the foreign parties that are suitable and willing to cooperate. The assistance could encompass the work of one or two an experts for a year in establishing the connection, and a similar amount of work for training the personnel to keep up the linkages and inform local firms about the connections.

- To be able to spread information, the institution also has to have access to other regular sources of information. This includes linkages to the main databanks in their field of activity, good telecommunication connections abroad and a continuous flow of the most important business periodicals, magazines, journals and research publication series in their sector. Foreign aid could include the setting up of these information sources, as well as aiding the institution in library development and informatics questions.

- In spreading technology information to the member organizations, the institution could use seminars, conferences and also more informal get togethers. To be able to reach even the smaller firms, relatively short meetings - half a day seminars - are often the only possibility. The small firms do not usually have, not even in developed countries, personnel specialized in technology development questions. These are usually left, by default, to management responsibility of the managing director, who has very limited time to spend on not directly business related meetings and/or reading reports. A short meeting, however, may be enough to attach their interest to manufacturing technology development.

In this respect, international organizations can support the institution both in planning and arranging the meetings as well as transferring experiences from corresponding activities in developed countries. The external resource needs for such support are not very high, approximately two to three workyears of an expert or experts to get the activities started.

1.8 INFRASTRUCTURE NEEDS AT DIFFERENT LEVELS OF DEVELOPMENT

The details of the subprogrammes 1.1 to 1.7 will depend on the particular size composition and location of industry in the country. It will depend also on the shape and extent of existing infrastructure development. However, there are general characteristics, in terms of infrastructure needs, for countries at different broad levels of development. These are summarized in Table 8. It gives an outline of what types of assistance, and thus implicitly what possible combinations of subprogrammes 1.1 to 1.7, may be relevant.

Table 8. Infrastructure needs on different levels of industrial development

INFRA-STRUCTURE ELEMENT	THE STAGE OF STRUCTURAL CHANGE		
	(Mass production of) consumer goods and process industries as the key sectors	Capital goods sector as the key sector	Automation and high technology as key factors in industry
Physical infrastructure	Basic (power, roads, communications) physical infrastructure	Extension of basic infrastructure	Sophisticated telecommunications (eg. integrated digital services, networks)
Human capital infrastructure	Critical mass of civil, mechanic and chemical engineers and workers with basic skills	Critical mass of mechanical and electronic engineers, vocationally skilled work force	Critical mass of electronics engineers, computer specialists and physicists, technically skilled, flexible work force
Technological capabilities	(Mass) production and investment capabilities	Production, design and product engineering capabilities	Capabilities for (flexible) production and continuous innovation
Science and Technology	Basic (minimal set of universities and government labs)	Extension of basic science and technology infrastructure	Generic technologies, such as information technology and biotechnology
Marketing infrastructure	Probably scant (especially if commodities are homogenous and no export industry)	Overseas marketing research capabilities, data bases on export market, country's reputation in export markets	The same as on previous stage plus networks of overseas export firms
Financial infrastructure	An industrial development bank	An export development bank (for plant exports)	Venture capital firms and over-the-counter exchanges
Supportive company networks	Network of basic engineering firms	Network of suppliers of parts and components	Network of laboratories and R&D institutes, management consulting, science and technology parks, high-tech engineering firms

PROGRAMME 2: DIRECT SUPPORT TO MANUFACTURING FIRMS

This group of programmes included all kinds of assistance, from comprehensive financial/investment aid to limited consultancy, given directly to individual companies.

The type of support considered under this heading deals with existing companies - not with the creation of new companies or efforts to expand production into new industrial sectors.

Assistance to manufacturing firms in order to improve competitive efficiency may take several broad forms within UNIDO criteria, including:

- Company rehabilitation;
- Support for upgrading technological capabilities and the adoption of automation;
- Direct support in technology selection and the conducting of feasibility studies;
- Support in trouble shooting.

2.1 COMPANY REHABILITATION

Introduction

This subprogramme deals with comprehensive rehabilitation programmes that include a focus on:

- Automation;
- Production technology development;
- Business strategy development (with automation targets).

In providing support to companies under rehabilitation schemes, development cooperation agencies usually intend to enhance local capabilities. Given that these are limited, the rehabilitation process of a company should take the local reality of the market fully into account, in order to optimize the use of them. An exhaustive study of the company environment should always be a first step in rehabilitation programmes.

Although each developing country has its own characteristics there are some important general elements that will normally act as obstacles to carrying out the changes proposed. Some of these are as follows:

(i) **Conservative attitudes** amongst owners, employees, and managers. This is in part because of an established framework of relationships between the different actors. In many cases these are medium to large firms in which an established "status quo" exists. In particular, when the companies are state or parastatal companies, their freedom of action to change technologies, or organizational structures is somewhat limited by the state. With CIM goals, this is a crucial barrier to be overcome.

(ii) In most developing countries, a second major weakness will be **the poorly developed educational, and skill base** of both its managerial elite and its blue collar

workforce. In order to achieve (i) above a drastic upgrading of the skill base is essential, and one that is directed towards long-term needs.

(iii) A particular area of difficulty faced in both (i) and (ii) is that faced by small companies related to their **disadvantaged position in the industrial environment.** Lack of financial resources, poorly developed contacts with other industrial sectors, a disadvantageous position in relation to purchasing components or materials, lack of adequate information or contacts with powerful government departments, inadequate trade and technology policies, and poor export orientation, all act to retard development. Steps should be taken to reduce these obstacles: as can be seen, the necessary changes do not always require additional resources, but a better perception of the needs of industry among those who condition its environment.

(iv) The **logistical framework** is usually a fourth and considerable difficulty for established companies -- as it would be in the creation of new companies. A prime criteria for efficient production, particularly in the field of exports, is clear, uncluttered, regular, and consistent contact with the market place. Also needed are effective road, rail, sea and air links with the markets to ensure prompt delivery of goods in order to meet the needs of the national and international customer. Low prices are no longer enough on their own to ensure market success.

(v) Existing companies who are supported under this programme are often substantial employers in the areas in which they operate. This may contain the seeds of considerable **industrial unrest** unless action is taken to ensure a clear exchange of information.

(vi) The types of changes required at both the technology and organization level is so profound as to call for long-term strategies of development. This is a difficulty for many countries, and the companies within them that are continually carrying out "fire-fighting" exercises to remain solvent. It is difficult in these circumstances to advise companies/countries to adopt a more coherent approach to industrial strategy and planning. It is, however, essential that this is done.

(vii) The final barrier discussed here, though certainly the list is not exhaustive, is that regarding the technologies themselves. In the developed countries a whole range of technologies is becoming integrated in a systemic fashion. Even these affluent countries with their vast resources of funding and technical expertise has faced - and still face - huge problems in integrating the hardware and software of highly dissimilar processes. Similarly, the organizational adaptation required to effectively use these new systems is highly complicated. Some countries, such as Japan, Sweden, and Germany, have shown a much higher propensity to use the new systems efficiently due to their higher levels of education, skills and training, and their ability to adapt rapidly. The problems faced by developing countries are, therefore, huge ones, requiring a deep understanding of the changes inherent in the new technical and organization innovations.

In noting the weaknesses and problems faced by established companies in the field of international competitive efficiency it should also be pointed out, however, that there are strengths and opportunities to be derived from long-term strategies based on: up-graded

education and skills; improved logistical networks; improved inter-company contacts, and the up-dating of technologies, etc.

The size of the company

Depending on the size of the company there will be different strengths and opportunities that may provide the framework for company development. Some of them are listed below:

(a) A major strength of medium- to large-sized **established companies** is the **framework of existing contacts** they have with other industrial sectors; materials, component and equipment suppliers; and government and/or industry research institutes, and educational bodies. Such companies face much less of a problem than the smaller or more recently established firms in discussing, negotiating or introducing change, provided that the incentive for change exists. Political, as well as economic, strength is often a prerequisite for change and such companies are more likely to possess it.

(b) As noted above, **financial resources** are an imperative for the introduction of new technologies if these are not available through direct foreign investment or assistance, or through foreign countries' gifts or international agencies purchasing arrangements. It is likely that the larger, established companies have these resources and are more able to introduce such technologies as CAD, NC equipment or Robotics - if these are appropriate to their industrial sector. These larger enterprises are also likely to be able to use their greater size and purchasing power to negotiate more favourable terms in the purchase of the necessary materials, equipment and services.

(c) A third strength of the companies whose rehabilitation is being sought is that they are likely to **possess larger numbers of the educated, skilled and trained personnel** necessary for the introduction of automated technologies. There are several reasons for this being the case, these include:

- A larger company usually contains better opportunities for individual advancement. Larger enterprises may attract such individuals who are not disposed to start new enterprises.
- The levels of wages/salary may be higher in these established companies, providing a strong financial incentive.
- The attrition rate in small companies, even in the developed world, is quite high, therefore, prospective employees may view the greater job security in larger companies as attractive.

(d) Larger established companies also offer considerable opportunities for advancement given the support of international agencies. A major opportunity is that offered by a careful and considered **restructuring of the company**. In this instance international experts can provide up-to-date advice, based on best practice developed country techniques, which can aid the breakdown of inefficient hierarchies and increase the range of job knowledge of individuals away from a functional specialization approach to a broader, more effective use of human skills. This can provide the impetus for the successful adoption of appropriate technologies.

(e) In the up-dating of production processes and equipment a considerable opportunity exists for training and educating the existing workforce. Almost all equipment/software suppliers offer **training programmes** on their products. This may range from short on-the-job training post-installation, the least satisfactory form of training, to extensive training in their own factories. Larger established developing country companies are probably in a better position to exploit these training opportunities than smaller companies, and may become a significant source for the diffusion of automated technologies to other companies, or sectors of the economy. The demonstration effect of the use of such technologies may become a powerful source of change throughout the economy.

(f) Finally, very few of the smaller companies in most developing companies, although still important providers of employment, are involved or interested in **export markets**. While developing countries may have been focused mainly upon import substitution as a prime goal, this may not have been too important in the future. It is increasingly clear that an important source of national development in the Republic of Korea, Taiwan Province, and Singapore for instance, has been export promotion. Here the role of the larger companies with their international contacts and markets has been crucial. The creation of a powerful and vigorous export market may become an essential feature of development, and the support of the international community in improving the effectiveness of large established companies may pay considerable dividends.

In this evaluation of the strengths, weaknesses, opportunities and problems faced by established companies, only a brief picture has been painted. The sheer complexity of the situation - varying across branches, countries and regions, makes it difficult to specify a unified policy for change. Taking this into consideration, some very general ideas of possible programmes for company rehabilitation are given below.

2.1.1 Problems in attitudes of the actors

The established framework of relationships between the different actors (owners, employees and managers), inside an enterprise normally embodies conservative attitudes. Modern industry thinking, on the other hand, is based on more cooperative and unstructured relations. The question of attitudes is the first one that should be tackled, when a programme on company rehabilitation is begun. In most cases, the conservative attitude is based on a feeling of fear. The actors are normally afraid to lose their position (privileges) in the structure, and this is normally only because of a lack of information of the role each of them has to play in the production game. This is often the case in large companies, especially if they are of a statal or parastatal nature. Therefore it will be necessary to give some informative seminars, showing the importance of each part of the production process and the benefits of cooperative and non-hierarchical thinking. In most cases there will be some additional structural or organizational problems. To solve not only the general information problem but also the more specific one, the following steps could be undertaken:

- The first step should be to give some background information to the people working in the industry. This could be done through at least two seminars of approximate two to three hours each:

- An informative seminar for management, owners and high level employees (supervisors) about modern industrial thinking, including different examples.

- An informative seminar for employees about the industrial structure, with special attention to the responsibilities and obligations of each link in the production process.

- The second step should be an analysis of the structure of the industry. This should be based on interviews and discussion with the personnel. As it is not easy to break the first barrier of communication it would be desirable that the same person that gives the seminars also carries out the interviews and discussions. This step could be done by one expert for one week for the information collection and between two days and one week for the preparation of a report and perhaps also a presentation of the results. In the recommendations some possible ways of facilitating the communication and the problem solving activities inside the factory should be included (proposals such as mail box, trouble shooting meetings, etc.).

- The third step should be based on the second one and should include some formative seminars on the specific problems found for the people involved in them. Also, the use of the proposed lines of communication should be explained in detail (how to use them, what benefits they will bring, etc.)

2.1.2 Problems of skill shortages and quality deficiencies

In many cases the lack of competitiveness of a firm is related to shortages of skills in specific, critical areas. In some cases these insufficient skill levels result in a poor quality of the final product. Such problems could be addressed through the following steps:

- Study of the firm focusing on the areas of lower productivity, but understanding the firm as a whole. The result could reveal problems of different kinds, in particular those related to existing skills or to a lack of quality assurance or at least quality control. For this step an expert would be necessary for at least one week to determine the critical areas, a second week to determine the necessary skills or quality control procedures and a third one to prepare a report on the problems found and the possible solutions. It could be also possible that this study reveals a poor quality based on technological reasons. In this case a subprogramme of the type 2.2, proposed upgrading technological capabilities, and the adoption of appropriate automation, would be necessary.

- On the basis of the report of the first step, prepare the content of the necessary courses. As the courses or seminars will be given only once it would be preferable to have it given by an expert and not to train a trainer specially. The preparation time required will depend on the type and amount of the necessary courses.

2.1.3 Deficient external linkages

This programme should aim to create or strengthen, if it already exists, the framework of contacts the firm has with other industrial sectors; materials, component

and equipment suppliers; and government and/or industry research institutes, and educational bodies. Especially small- and medium-sized companies face the problem of being not strong enough in discussing or negotiating with suppliers. These smaller enterprises may need assistance to negotiate more favourable terms in the purchase of the necessary materials, equipment and services.

Access to information about national or international credit lines or special regulations is normally a problem faced by smaller companies. The growing pervasiveness of international product standards and quality requirements makes this a particularly acute problem.

For solving such problems, a subprogramme of the type 3.2, linkage/network creation and in establishing logistical connections between companies, could be initiated.

2.1.4 Comprehensive repair and replacement of equipment

See subprogramme 1.4, establishing/strengthening institutions for production services.

2.1.5 Deficient logistical infrastructure

This kind of assistance is concerned with the direct logistical frameworks such as access roads, energy supplies, etc. In many cases in developing countries, for example the transport cost plays a decisive role in the competitiveness of the product. In many other cases the problem is related to insufficient support infrastructure in an industrial area. In this kind of problems the solution may be a straightforward one of building, or strengthening the necessary framework. Such capital investment projects are outside the scope of this programme, but identification of the need for them is not. This should be acdressed as follows:

- A study of the environment for the selected industry should be carried out, although in many cases the solution should be planned for a group of industries, sharing the same infrastructure. This study could be made by an expert for a period between one week and one month depending on the size of the firm or group of industries to be assisted. The study should include discussions with the local authorities aimed at coordinating the solution with local initiatives and possibilities.

Timeliness and speed of delivery affect the ability of a firm to respond to changing market requirements. Often the transport problems are not only related to the physical infrastructure but also to the procedures associated with transport: customs clearance, documentation, licenses, etc. Analysis of the transport problem may highlight such issues, which is dealt with under 1.6.3.

2.1.6 Recurrent input requirements

The objective will be to provide recurrent input requirements, including raw materials, spare parts and components to key enterprises in order to restore their capacity utilization. Specific targets should be set for some incentive good industries, industries producing intermediate inputs and raw materials, and those generating revenues for government. The activities would include:

- Assessment of requirements;
- Design of mechanisms for assured supply (revolving funds, etc.);
- Mobilization of international support (development finance, commodity aid, etc.).

See also subprogrammes 1.1.4 and 1.1.5.

2.2 UPGRADING TECHNOLOGICAL CAPABILITIES AND THE ADOPTION OF AUTOMATION

Under this heading, many types of activities supporting companies may be included in upgrading their technological capabilities, e.g., organizational development, business/production strategy formulation training, general equipment modernization, implementing new production control systems, giving direct assistance to automation investment projects etc. These are analogous to rehabilitation programmes in that the whole company is involved, but the firms concerned will be at a more advanced level and in better shape.

Such support can be applied both to established companies that are perhaps at a higher level of automation, and to those smaller and/or newer companies, attempting to increase further their production effectiveness.

This support can be provided in a number of ways relevant to technological up-grading:

- General equipment upgrading
- Business/production strategy and manpower options
- Direct investment
- Organizational development
- The introduction of production control and quality control systems
- Adoption of automation

2.2.1 General equipment upgrading

Support given to improve overall efficiency may involve raising the level of technologies employed. In general this tends to focus on four basic areas:

- Computer aided design (CAD)
- Numerically controlled equipment (NC)
- Robotics
- Flexible manufacturing systems or cells (FMS, FMC)

However, two points need clarifying here. Firstly, these technologies have varying degrees of complexity within themselves, e.g. ranging from simple $5,000 PC based CAD to $500,000 mainframe based CAD; or from $200,000 FMC to $25,000,000 FMS. They also entail considerable differences between themselves regarding their degree of sophistication, complexity and difficulty of operation, e.g. a simple CAD system is a far less complex technology to operate or manage than a sophisticated FMS.

Secondly, taking, for example, NC equipment, the diversity of applications and variation of technologies within the sphere is considerable, e.g. NC controlled equipment may range across numerous industries from process controls in the food or chemical

industries, to electronic sewing machines in the garment industry, from phototypesetting or electronic controlled printing presses in the media sector, to furniture making in the household supplies sector, from metal cutting in the automobile or aerospace industries, to casting or forging equipment in the basic metal industries.

These facts suggest that unless a fairly developed infrastructure exists, for example, high levels of education, skills and training, effective logistical systems, competent management practices, etc., international support should be focused upon the more easily applied technologies, e.g. PC based CAD, and NC equipment of fairly low grade sophistication, so that the utilizing countries or companies can build up their expertise, and make these technologies the basis for future development.

They also suggest that the application of these technologies should not be aimed at high capital cost industries, such as automobiles or aerospace, but at the basic metalworking, woodworking, glassware, plastics, textiles, clothing and footwear industries.

2.2.2 Business/production strategies and manpower options

Inherent within the radical changes contained in the adoption of new technologies are the changes in the business or production strategies needed to use the technologies effectively. These are discussed in more detail in the study on trends in industrial automation.[7] The main issues can be summarized as follows:

- Demonstration and diffusion effects
- Logistics
- Supplier links
- Information links and resource sharing possibilities

Demonstration and diffusion effects

A variety of studies into the application of new technologies in the developed countries have highlighted the fact that a significant change in traditional business/production strategies is necessary. They derive from observation of changes resulting from, or brought about by, the technologies.

Concerning the demonstration effects, it is clear that many customers are likely to be markedly influenced by seeing new technologies in operation - particularly where quality improvements, improved productivity effects and possibly, reduced prices are incurred. This is one element of the less quantifiable biases contained within the adoption of new technologies. A second, but equally important impact, is that on competitor companies. Clearly a general upgrading of technology is likely to follow if a leading company introduces the new technology. Companies will perceive that the technology leadership must be matched in order to remain competitive. There is actually an added benefit for the "followers", because this strategy may entail substantially less risk.

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[7] "Trends in Industrial Automation", UNIDO, PPD.231(SPEC.), 12 October 1992.

Equally, where a technology is applicable in a variety of industries, and CAD is a classic example of these, other industrial sectors may be able to obtain part of the advantages that can be acquired by a general increase of the skills and expertise created by the leader companies in another sector. For example, although the original users of CAD may be in such traditional industries as clothing or footwear, other industrial sectors such as in mechanical engineering, may benefit from workers trained in operating or maintaining such equipment.

Logistics

These have already been mentioned (under 2.1.5). They are crucial for technology upgrading, even though support for logistics improvement is not usually possible within the context of these programmes. However, without policies directed towards these basic issues, general development may be limited. Some of the more important considerations are:

- Power supplies
- Transport facilities
- Communication links

Power supplies: Considerable problems may be created if a sufficiently developed system of power generation and supplies do not exist. Much of the technology, which is computer based depends on regular and consistent supplies of energy in order that it works consistently and continuously. A failure to achieve this may mean lowered performance levels overall, a drop in quantity, reduced output, and in extreme cases a physical breakdown of whole system entailing loss of data etc.

Thus the provision of adequate power generation by the state - or by the using company, through company generators, etc. - is essential to the introduction of much of the technology.

While aid agencies can assist in the provision of experts and information, or assist individual companies in seeking alternative sources, the national governments must be the main actors. There is nevertheless scope for international support in assessment of the quality of electricity supplies, and in the development of (hardware and software) solutions.

Transport facilities: As with power supplies, the provision of an adequate infrastructure of roads, rail systems, airport and sea terminals represents a set of major capital investment projects, and is largely a government affair. However, there are a number of technical cooperation projects dealing with the means of transportation, for example, the training of maintenance personnel for the repair and reconditioning of lorries, railway rolling stock, etc. can be provided. This is essential since in many instances the capital stock may exist but is unable to be used because of deficiencies in its maintenance, or because of a shortage of spare parts.

Individual company assistance may also be provided by upgrading or introducing transport facilities within companies, e.g. the company fleet concept. Here again appropriate programmes of training, assistance in purchasing, expertise in scheduling, are all areas where substantial support is possible and desirable.

Communication links: The third, and major area for state development is that of the communications networks. The provision of telephone, telex and fax links between individual companies, and between such companies and their customers, suppliers and markets, nationally and internationally, is a necessity. Increasingly too, the establishment of satellite links between such bodies is growing in importance. Support provided in the selection, purchase, and including the physical infrastructure of land lines, transmitters, and receivers, makes a significant contribution to industrial efficiency.

2.2.3 Manpower issues

Manpower issues range across a broad area of involvement that is of crucial importance for business and production strategies. Such issues include:

- Education at the primary, secondary and tertiary levels
- Vocational training
- In-house and specific training
- Supplier training
- Other programmes

Primary, secondary and tertiary education

The building up of a literate and numerate workforce is part of the process of breaking out of the development stage and entrance into the developed group of economies. Basic literacy/numeracy was perhaps sufficient in the past for the establishment of a range of traditional manufacturing industries, but production based on information technology calls for much deeper and broader levels of education. Countries in the highest ranks of industry have made heavy investments in developing a broadly based and highly educated workforce. Such countries as Germany, Sweden and Japan come clearly to mind here and their transformation was no overnight change but one based on long-term, extensive and well-planned strategies. Newer developing countries and areas whose strategies have been similar are the Republic of Korea, Taiwan Province and Singapore. These educational changes have been based on development of the workforce by egalitarian means, and across all sectors of the educational system, primary schooling, secondary education, and at the tertiary level, and by rapid growth of university, high-school and similar institutions. Industrial development needs such growth outside the field of manufacturing itself in order to provide the brain skills needed for industrial training. Moreover, the institutions so developed (universities and technical institutions) often provide the only domestic source of R&D capabilities and consultancy sources.

Vocational training

Following on from the educational system as highlighted above is the related issue of vocational training. The provision of adequate facilities and resources to train the people who have already benefitted from such education will provide the essential level of skills for operating such systems as CAD or NC equipment. Such training is therefore the final and crucial stage of general programmes for human resource development. Programmes supported may be in such fields as:

- Technology up-grading
- The maintenance of equipment and logistical facilities
- The operation of computers and other electronic equipment
- The development of design skills
- The development of both product and process skills

In-house and specific skill development

Here the emphasis is on the creation of programmes to be implemented in-house in individual companies. Experience shows that virtually all formal and organized training for specific skills takes place in-house in the larger companies in developing countries. Such companies, therefore, carry a considerable burden of expense and responsibility in raising the overall national level of competence in companies.

Assistance to individual companies can take the form of the provision of facilities, the supply of experts or financial aid to institute such training. Whether this is best done through government agencies or directly to individual companies is uncertain, although the latter is probably preferable.

Given a large firm emphasis considerable spin-off effects may be felt in small- to medium-sized firms, and perhaps the large firm's facilities might be used by the smaller firms on payment of a fee. This would also ensure that such facilities were fully utilized.

Supplier training

The fourth (and perhaps in technology terms the most developed) form of training is that provided - either as part of a purchase package or as a separate facility - is that provided by the manufacturers of hardware of software. Here training in-house at the suppliers prior to installation is likely to be the most satisfactory, although this could also be done in-house during or after installation.

Other programmes

A range of other options is also available. Training or familiarization programmes could be mounted utilizing experts, e.g. on CAD. These could take the form of a travelling show, which could even make use of a fully equipped van or lorry containing equipment and videos, etc. Such a process would take the ideas and technologies to the potential users, e.g. local entrepreneurs, in their own region, i.e. major towns in their country. One advantage of such an approach would be a considerable time-saving for the entrepreneur - and therefore a greater interest in attending. Such an approach might be sufficient to raise the interest of the participant in further investigation of the technologies displayed.[8]

Similarly, static sites, e.g. in manufacturing industry centres staffed by experts, and perhaps equipped by major suppliers of equipment, would be another possibility for raising awareness and increasing familiarity with developments in industrial automation.

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[8] These ideas are already being tested in pilot programmes by UNIDO, in the field of technologies for the leather industries, as aprt of the Industrial Development Decade for Africa (IDDA) programme.

2.2.4 Supplier links

Shop floor level changes, such as implementation of new work organizations and introduction of advanced automation, are only one part of a business strategy of flexible specialization. The other part of the strategy involves changes in firm and business organization. Flexible production means more decentralized and informal governance structures. This includes both changes in the internal organization and also new linkages to outside organizations. This section deals with the second set of issues. The firm has to move from anonymous market relations based on money transaction towards more cooperative, long time development relations based to a growing extent on confidence and mutual dependency. The necessary strategic alliances have to be created in all directions, from the enterprise:[9]

- **Backwards in the production chain:** to a growing extent, intermediate inputs are obtained through long term subcontracting, where the partners are linked to each other by e.g. continuous technological development in both products and processes.

- **Forwards in the production chain:** finishing, marketing and other functions following the core activities are subcontracted in the same way as intermediate inputs. Technological links are involved here as well.

- **To supportive and complementary functions:** many supportive services are acquired through alliance creating contracts. This is especially typical for research and development functions but also for more common business services involving assets of medium specificity. Horizontal strategic alliances - e.g. in using same trade marks in marketing - are also created with companies whose product variety can be used to complement the firm's product range.

- **To competitors:** with the growing complexity of technology and markets, strategic alliances between competitors are becoming increasingly common. Alliances on basic research are most typical, but marketing alliances (e.g. as market cooperation limited to some regions) between competitors are not unusual either.

For small firms, linkages and creating networking relations are even more important than for large concerns. Even a technologically competent small firm alone is powerless without the necessary connections and linkages to all outside interfaces. This is especially true for companies in technologically developed sectors, where small firm resources and internal skills are inadequate even for many vital activities.

In many developing countries with incomplete industrial structures, the problem is more complicated. There will probably be insufficient potential partners locally to bring about the kind of networks needed. This points to the need for regional cooperation, and

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[9] In this connexion UNIDO is promoting the establishment of an International Centre for Advanced Manufacturing Technologies.

for explicit consideration of the requirements for these kinds of linkages when schemes for regional industrial integration are being prepared.[10]

2.2.5 Information links and resource sharing

In most cases, companies in developing countries have very limited resources, whether in terms of installed capacities, human resources, and industrial services. To optimize their use, there will have to be special efforts made to spread information, both within countries and, where integration efforts are under way, across subregions. The kind of information that needs to be diffused is of several kinds, but it includes what other industries have done and are doing about new technological developments.

The industry in a developing country may be faced with the difficulty that a study to solve a problem is too expensive. But probably another company in or outside the country has solved or at least studied this or a similar problem before. If this is not so, nevertheless it might be that if more than one company were to pay for the study, it could be possible to undertake it.

Access to international information (specialized magazines, proceedings of conferences and seminars, research reports, etc.) is not only expensive but also very time consuming. Therefore the information has to be made available in an organized way adapted to local requirements.

Industrial study tours to developed countries may be too expensive; given the necessary infrastructure, inviting people from developing countries to give seminars, or inviting vendors to show their products, may be a cheaper alternative.

A further consideration is that of what kind of new structures to manage resources that are too expensive to be considered by any one enterprise.

Typical problems and solutions include the following:

- Some parts of the product could be better made by a new specific machine, but the utilization rate of it would be too low to justify its purchase. Time sharing of the machine by different companies could solve the problem.

- Purchase of the machine can only be justified if it runs at least two shifts, but the overhead cost of working two shifts is too high. A subdivision or spin-off company working more than one shift for a group of industries could eliminate an important part of the overheads.

- The optimization tools (simulation, layout planning, material flow) are too expensive to be used. Again, the solution may be to centralize their purchase and use on some institution, such as a Chamber of Industry or club. This is particularly easy in this case because there will be one-off or

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[10] A basis for expanding linkage creation activities can be found in the UNIDO experience of establishing subcontracting schemes for industry at national and subregional levels. UNIDO's Investment Promotion Services (IPS) offices also provide a basis for broadening the scope of investment promotion beyond simple Foreign Direct Investment (FDI) towards the more technology- and services-driven type of alliances increasingly being established internationally.

occasional use by any one firm, allowing the broadest possible range of firms to use the tools (typically software, kits, etc.).

Further disadvantages may arise from the national market, which may be limited, with accordingly few domestic producers.

If the national market is too small, an international vendor of equipment will not install a technical support division; although if the necessary infrastructure is provided it could become attractive. National institutes for specific technologies giving the necessary support could solve the problem. In general, a national body specializing in the branch in question is more likely to be able to provide the support in the form the producers need. But suppose there is no such institute that could appropriately provide the technical support required? In this case a subregional body may provide a solution. Again, it will be better if the body is not too broadly focussed.

Technical cooperation programmes in this filed could concentrate on the support for building up a selected institution to play such a supportive role. Again, as discussed, the need may be met by an industry club, on which see Box 1 for more details.

2.2.6 Associated organizational development

As this is normally related to the whole structure of the company and not only to the upgrading of technological capabilities alone, it has been covered under 2.1, company rehabilitation, above.

2.2.7 The introduction of production control and quality control systems

An important part of the industrial revolution in Japan began in the middle of the 1970's with the experimentation and adoption of a whole range of new manufacture management approaches to improve overall productivity and eliminate waste. This new approach was first called the "Ohno System" (in honour of Taiichi Ohno, who masterminded the Toyota system), or simply the "Toyota Manufacturing System". In trying to find a "better" name, the idea was mostly mis-named. Some of these examples are the "Kanban System" (referring to one of the main elements of the system that was a pull scheduling technique using "kanbans", meaning "container" in Japanese), "Zero Inventories" or "World Class Manufacturing" and "Continuous Flow Manufacturing".

The concept of quality is often associated with these ideas, because they can all be related to the satisfaction of consumer requirements, which will include, at a minimum cost, timeliness and quality considerations combined. There is little point in producing a product quickly, cheaply and inaccurately. The growing emphasis in international trade on product standards[11] is one manifestation of this concern. However, there is also a new emphasis on process standards, those which determine the acceptability of the way in which the product is produced. The best known of these standards, the ISO 9000 series, is a statement about the quality of the producer firm and its methods, and thus, by implication about the goods it makes (or the services it provides, because the ISO 9000 series also covers services companies).

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[11] "International product standards: Trends and issues", UNIDO, PPD.182, 7 January 1991.

There is new enormous interest, in both developed and developing countries, in the ISO 9000 series and its rationals. Many enterprises are actively seeking to reform and upgrade their processes so that they may be certified as complying with ISO 9000.

Total quality management (TQM) is a more general concept that embraces ISO 9000. Therefore both elements of a production control system: an optimized planning mechanism, like JIT or OPT and a continuous quality level, through TQM will help to increase considerably the effectiveness of a company in meeting its objectives. The dual approach and its requirements can be summarized as follows:

Total Quality Control: In the competitive business climate of today, quality is no longer an option; it is a positive requirement without which an organization cannot survive. Quality control systems can introduce improved productivity, committed customers or improved certainty in operations. However, one of the decisive factors in achieving results such as these is a commitment by the management, starting from the chairman and ending at the production line. Total quality must be management-led, company-wide in implementation, dedicated to continuous improvement, and the responsibility of every employee. Technical cooperation programmes can assist firms to assure optimal results by the introduction of quality control programmes. These programmes should be in three stages:[12]

- Presentation of the ideas of TQM and study of the actual production system, the requirements of the actual markets, and the necessary changes to access other possible markets;
- Seminars on TQM methodologies and possibilities (including ISO 9000);
- Consultancy for the step by step adoption of the selected TQM mechanisms.

Just-in-time production: The key philosophies of JIT are simplification and continual improvement. The most important techniques and approaches associated with JIT could be divided into three main areas: manufacturing techniques, production/material control and inter-company JIT.

- Manufacturing techniques:
  - Set-up time reduction: such as the SMED system (single-minute exchange of die);
  - Pull scheduling: such as the KANBAN principle; the use of the smallest possible machine; the "preventive maintenance"; the "Poka-Yoke" system; etc.;
  - Cellular manufacturing. Group technology.

- Production/material control:
  - JIT-MRP (Material requirements planning);
  - OPT (optimized production technology);
  - Schedule balancing and smoothing through "under capacity scheduling", "visible production control" or "load-oriented release of orders";
  - Simultaneous material and time management.

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[12] UNIDO is already implementing similar programmes (for instance in Egypt). However, it is clear that the requirements of developing countries and the changes brought about by industrial automation will make them even more significant in the future, as part of the wider programmes of response.

- Inter-company JIT
  - Application of the JIT principle on an inter-company basis, requires that goods are supplied in small quantities, exact amounts, at frequent intervals and at 100 per cent quality. The techniques utilized include single sourcing, use of standardized containers, supplier quality certification, point-of-use delivery, family of part sourcing, purchasing Kanban and above all mutual trust.

In a general way JIT is an approach for the cost-effective production and delivery of only the necessary quantity of parts, at the right time and place, at the right quality, while using a minimum amount of facilities, equipment, materials and human resources. JIT is dependent on the balance between the supplier's flexibility and the user's flexibility. It is accomplished through the application of elements that require total employee involvement and teamwork.

The three application areas mentioned above are potential fields for technical cooperation to assist firms to assure optimal results by the introduction of JIT programmes. The last one, inter company JIT will be treated in the programme 3.2 below on direct support in linkage/network creation and in establishing logistical connections between companies. For the other two the assistance could be based on a three step process:

- Presentations of the ideas of JIT and study of the actual production system, the requirements of the actual markets, and the necessary changes to access other possible markets;
- Seminars on JIT and other production planning methodologies and possibilities;
- Consultancy for the step by step adoption of the selected JIT mechanisms.

2.2.8 Adoption of automation

The most important element in the adoption of automation technologies is to be aware of the possibilities and risk involved in this process. The organizational and economic consequences of the introduction of new automation technologies in the company and their environment will be of crucial importance. Assistance will be needed in this area, and it should include two parts:

- *A visit to the company*

  The first part of the assistance is to determine together with the company the type of automation that should be necessary. This could be done by one expert visiting the company for a time between one week and one month (depending on the type and size of the company). After discussing the different possibilities, a report on the envisaged technology to be adopted should prepared. This report should be used for the next step.

- *A seminar on the automation and its effects on organizational and economic structures*

  On the basis of the first part of the assistance, the second step will be the holding of a seminar on the possibilities presented by the selected automation technologies

and the effect their introduction could have. The main lines of the seminar programme could be the following:

- **Target group/participants:** representatives from different levels of the company, including owners, senior and junior managers, supervisors and workers' representatives.
- **Duration:** three days
- **Programme:**
  First day: Presentations by one expert in the field, from similar processes in companies from developing and developed countries, showing their experience of the introduction of new automation technologies. Presentation by selected national and international vendors of the required technology and the possibilities offered by the different vendors.
  Second and third day: Team work to select the machines and tools and to prepare a preliminary schedule for the step-by-step introduction of them.

2.3 DIRECT SUPPORT IN TECHNOLOGY SELECTION AND THE CONDUCTING OF FEASIBILITY STUDIES

2.3.1 Technology selection

The problem of technology selection may be related to the equipment, to the materials or to the software. The possible steps and the necessary assistance could be as follows:

Equipment selection

- Assistance in carrying out an in-depth study of the needs of the firm in order to determine the requirements for the new equipment. Depending on the size of the firm and the problem to be solved, this could be done with the assistance of one expert for a period ranging between a couple of weeks and three months.

- Using the results of the first stage to determine the area and select the people to be involved in this second stage, there should be a seminar with a presentation of the state of the art in the field. Normally with the acquisition of a new equipment not only a specific training of the operators should be included but also a general informative seminar for the people related to it both directly and indirectly. This usually happens in developed countries, but in developing countries in many cases, after buying equipment there is a lack of information about the implications of the equipment for the whole factory. If the personnel related indirectly to the equipment, such as production managers, accounting people, or the marketing department, are not aware of the possibilities raised by the equipment, such as accuracy, repetitivity, etc., some important side effects of the acquisition will be missed. For this reason, assistance through an informative seminar about the technology used by the new equipment, the production possibilities it has, the accuracy, etc. would be necessary. The expert making the presentation should be supported by people of other companies in the same or other countries showing their experience and the problems they have had in the past. In addition, there

should be presentations of possible equipment, by representatives of the supplying companies.

- Following the seminar there should be a discussion with the different vendors, and perhaps also with people from the other companies about the advantages and disadvantages of each of the possibilities. Before this discussion it would be useful to prepare a questionnaire, including possibly some selection matrix, to be used as a basis for the selection. The following points should be discussed:

  - Equipment operation: With the acquisition of the new equipment it is essential to include specific training for the operators. In addition, the firm should ask the vendor to include a seminar about the operation of the new equipment not only in standard situations but also in non-standard situations to allow the personnel to solve some of the possible problems *in situ*, without depending on the usually very expensive assistance of the vendor.

  - Fine tuning of equipment: In many cases it will be necessary to adapt the functioning of an equipment to the specific production condition of the firm. Normally operator skills are not sufficient for optimization of the use of the equipment under the specific firm production conditions. Especially in sophisticated machinery, incorrect fine-tuning could represent a loss of productivity. The vendor should therefore support the firm with specialized personnel helping in this procedure. The assistance should include not only the direct solution of the problem, but also training for the operators, in order to allow future improvement on-site without external (expensive) advice. Also in this stage the firm should take into consideration possible future production conditions, such as changes in the materials used, changes in the product dimensions, new product production, etc. These should be discussed with the vendor to determine the flexibility of the equipment.

  - Hardware-Software integration: In many areas there are no defined communication interfaces or protocols between products of different vendors (in some cases also between products of the same vendor). The integration of the different elements in such cases requires an in-depth knowledge of the hardware and software involved, and this is normally not available in the firm. This problem should be discussed with the vendor, not only in relation to the actual tools available in the firm, but also to those planned to be acquired. Among typical problems may be the following:

    - CAD↔CAM interfaces (Post-processors are required)
    - Data acquisition systems↔Data bases communication (interfaces are required)
    - Communication between different networks (gateways or transducers are required)
    - Communication between different databases, e.g. production and financial database.

- The final step should cover assistance in the discussion an negotiation of the terms of the agreement and the preparation of the contract between the vendor and the firm.

2.3.2 Material selection

In some cases the problem of competitiveness is related to the materials used in the production. The problem could be in connexion with environmental matters or with the material characteristics. Assistance in the selection of new materials, or for the change to cleaner production processes will be useful in these cases. The assistance should include:

- A study of the firm to identify the critical areas in detail.
- An information seminar on the different possibilities.
- A discussion with the staff concerned to answer specific questions and to select the new materials or processes.

2.3.3 Software selection

Assistance for the selection of a software package should include:

- A study of the firm to identify the critical areas.
- A informative seminar on the different possibilities.
- A discussion with the personnel to answer specific questions and to select the new software.

2.4 FEASIBILITY STUDIES

2.4.1 Simulation of layout

This planning phase is normally a critical one, because wrong decisions could represent in the future higher costs, through e.g. long internal transport routes, unbalanced equipment, inventory problems, transit problems, etc. The best way to avoid this kind of problem is to use a simulation tool to play the game of "what would happen if ...". Today's simulation packages or languages are very powerful, but require a good knowledge of the software in order to use their full potential. Since the process of planning a new layout is not required very often, firms do not in most of the cases have the necessary skills to solve this problem by themselves. Assistance through an expert in this stage would by very helpful in order to obtain optimal solutions. The assistance could consist of a first part, where the model is prepared by an expert in close relation with people of the firm, and a second part where different variants of the model are introduced to examine side effects and possible optimization of the layout. Depending on the size of the factory, this assistance could be provided by an expert working in the preparation of the model for a period of time between one month and three months and a later assistance in the optimization phase for a period of between a couple of weeks and a couple of months.

2.4.2 Simulation of transport elements

This is similar to the point above (Simulation of layout) but concentrating on the transport elements. Again, since the process of determining the necessary transport elements is not frequent, firms in most cases do not have the necessary skills to solve this problem by themselves, and assistance from an expert would help in obtaining optimal solutions. The objective would be to determine the type and quantity of transport devices (ranging from Automated Guided Vehicles -- AGV -- in the most sophisticated cases to

simple transport units in the less sophisticated cases). Depending on the size of the problem, and the transport elements involved, this assistance could be done by an expert working in the preparation of the model for a period of time between a couple of weeks and a couple of months, with follow-up assistance in the optimization phase for a time between one week and one month.

2.4.3 Simulation of product-mix

This activity is similar to those above, but concentrates on the product mix. However, planning of product-mix is a process that may involve frequent changes depending on the flexibility of the equipment, the availability of raw materials and the changing pattern of demand. The assistance through an expert in this stage would again be very helpful, not so much, however, in order to obtain optimal solutions at the time, but to help in building up the analytical capabilities. The enterprise would, as a result, be able to determine optimal product sequences and combinations in order to reach the best production conditions (highest machines utilization rates, lower waste levels, etc.) in the light of changing external conditions. Depending on the size of the problem, and the amount of different products involved, this assistance could be provided by an expert working in the preparation of the model and giving training in its use. This could be for perhaps one month, with later occasional assistance of perhaps one week at a time.

2.4.4 Simulation of control systems

For many sophisticated and complicated control systems it is not possible to generate a mathematical model to assure the security of it. In these cases the simulation of different failures, production situations, machine breakdown, etc., is a very helpful approach. The process of planning a new control system is a fairly fundamental one, and companies do not usually have the necessary skills to solve this problem by themselves. Assistance from an expert would concentrate on the control system governing the production, not in changing the amount of machines, their configuration, or the product mix as in the assistance types mentioned before. Depending on the size of the problem, and the type of production process, this assistance could be done by an expert working in the preparation of the model for a period of time between a couple of weeks and a couple of months and a subsequent assistance to refine the system for a period of one to three months.

2.5 SUPPORT IN TROUBLE SHOOTING

Under this heading, the question of assistance to companies in trouble shooting in problems related to production technology is examined. This kind of project is intended to meet the short-term requirements of high priority projects in the industrial sector. Addressing needs that cannot be programmed in advance, such projects operate mainly through the expeditious provision of expert advisory services. Normally such projects should not exceed three months, but exceptionally the duration may be up to six months.

Equipment will not normally be financed under such projects. Only in exceptional cases could it be financed if it is necessary for testing or demonstration purposes.[13]

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[13] This is the basic framework of the Special Industrial Services (SIS), which are provided by UNIDO in a wide range of industrial fields. The present section of the programme indicates how the particularly important characterstics of the SIS programme (timeliness, high-level) would apply to urgent requriements

Possible areas for the application of this kind of projects would include:

2.5.1 Seminars for trainers

The general level of competitiveness of a firm and its ability to implement industrial automation are strongly related to the skills of the workforce. If there are no training possibilities outside the company, which is normally the case in developing countries, the firm itself will have to meet all the training needs. Assistance in the preparation of the necessary trainers will be necessary. The seminar for the trainers should cover teaching skills, presentation possibilities, experience in the managing of working groups, some psychological aspects, etc.

2.5.2 Introduction of control systems

In many cases the problem of productivity is related to an inadequate control system, for monitoring, quality inspection, data acquisition, etc. The type of control systems could be one of the following:

- On-line control: the monitoring signals are obtained from and/or control commands are sent to the manufacturing machines/processes in real time, that is, the control command is applied immediately upon receiving the monitoring signal.

- Off-line control: the acquisition and storage of monitoring data from the production line and the subsequent decision making and application of control commands occur at different times.

- Closed-loop control system: derivation of monitoring signals, their evaluation, decision making and application of control commands all happen automatically according to system's preset values. In other words, monitoring signals are directly affected by the control commands, and *vice versa*.

Depending on the size of the machine, group of machines or production system to be controlled, the assistance could be provided by one expert for a time ranging between a couple of weeks and several months.

2.5.3 Upgrading of equipment

When discussing an increase in productivity or the production possibilities of a firm, the question arises of whether it would be enough to upgrade existing equipment or if it would be necessary to buy new equipment. Assistance in this stage could be important in reaching the best solution for the company, rather than the best sale for the vendors. Depending on the type of equipment this could be done with the assistance of one expert for a period ranging between one week and two months. The assistance could include a seminar with presentation of different equipment upgrade possibilities by representatives of the supplying companies.

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in the field of industrial automation.

2.5.4 Upgrading of software

Software packages are usually improved by their producers and then released on the market displacing the previous version. An upgrade is the process by which a previous purchaser of the old version can obtain the new version at a concessional price. However, the upgrading procedure of a software package is not always a straightforward procedure. In many cases a firm continue to upgrade the software packages of a specific vendor only for the sake of simplicity and without taking into account what other software packages may exist on the market. Sometimes the extension of a software package through the addition of some modules of a different vendor, or even the total replacement of the package by a different one, could be the optimal solution. Firms do not like this procedure because it represents for them a high risk related to compatibility problems in the case of addition of modules and to an important investment (and probably a change in the user interface) in the case of a change of vendor. Since the software market is rapidly expanding and changing, where a new development could represent an important reduction in operating time, it could be helpful for the firm to receive external and, most importantly, "vendor independent" assistance. Depending on the type of software and the size of the firm this could be done with the assistance of one expert for a period ranging between a couple of weeks and a couple of months. The assistance could include a seminar with presentation of possible software packages, by representatives of the supplying companies.

2.5.5 Selection of methods and systems for quality control

One problem for many companies in developing countries is the low quality of their production. Not all the causes are within the control of the company: they can include poor materials, unreliable public power supply, etc. However, with respect to the possibilities for the enterprise to improve the quality of the products, methods and systems for quality control and quality assurance will have to be introduced. The selection of the methods and systems that would be best suited for the characteristics of the firm, the process, the product and the personal involved will require an assistance of a quality expert in order to reach the proposed targets. The expert will give advise about which method or system to use and where to applied it (Statistical Process Control, Closed Loop Control, Control by operator, Control by supervisor, special control devices, etc.). Depending on the type of product and the size of the firm this could be done with the assistance of one expert for a period ranging from one month to six months or even more. The assistance could include a seminar where possible quality control methods and systems would be presented and a posterior discussion with the people involved in the production process.

2.5.6 information collection

Strengthening the ability of firms to access important information sources needs several types of assistance, including: Aid to link the firm to the main data banks in its field of activity. This often has to be accompanied by an overall computerization of the company or by a modernization of the computer systems. International cooperation could also include financial support for the running costs of data bank connections.

The type of support could consist of three parts:[14]

- Assistance in the selection of the required hardware and software as well as the different possible access type to the database. This could be done through the assistance of one expert for two weeks.

- Assistance in selecting and establishing the connection with different databases all over the world and for the preparation and set-up of the database, up to the functioning state. This could be organized with the support of one expert for two months.

- Assistance in training the personnel to continue the connections, to maintain the database, and to manage access to information for the local industries. This could be done through a specialization course of two to three weeks for the personnel involved.

Other support will include strengthening other telecommunication contacts between the firm and developed country's institutions, e.g., through the acquisition of telefax or electronic mail equipment for the firm. The possibilities will, however, be dependent on the national telecommunication system.

2.5.7 Negotiation and contractual agreements

Services relating to the preparation and implementation of investment projects, related to automation problems in the industry in respect of specific questions as negotiations with third parties regarding contractual agreements.[15]

2.5.8 Selection of vendors

With the increasing spread of international standards and the trend towards open systems, it is likely that, for at least part of the equipment or services to be acquired, a number of potential suppliers may be available. (As against this, the basic pre-conditions for selection will include the availability of adequate support facilities in the developing country concerned). Technical support in the form of an international expert may be required in:

- drafting requests for proposals or product specifications,

- evaluating these and making recommendations on their acceptability both in technical and economic terms.

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[14] UNIDO implements numerous projects of this kind, in relation to UNIDO's Industrial and Technological Information Bank (INTIB), the setting up of national and suregional industrial information networks, and the establishment of national and subregional focal points for INTIB.

[15] This is an area in which UNIDO has a considerable body of experience in connection with the general question of technology negotiation and acquisition. Training courses, manuals, and technology acquisition information networks (thei TIES sytem) are some of the operational tools already available which can be employed in the specific field of industrial automation equipment and services acquisition.

2.5.9 Networking a local firm (or firms) with foreign technology suppliers

To strengthen this activity, international support can help the firm in choosing and creating cooperative linkages with suitable foreign organizations. The assistance could be of three types:

- Assistance in studying the integration of the firm in the local industrial structure, to find the specific areas where international networking would be particularly helpful. This could be done through the assistance of one expert for one month.

- Assistance in establishing the links with different suppliers. This could be organized with the support of one expert and representatives of commerce chambers from developed countries to find the possible counterparts in developed countries. After this step, representatives of the sectoral organizations and/or chambers of commerce and/or others, should be supported in the formal aspects of the bilateral contracts.

- Assistance in training for maintaining the linkages. This could be done through a specialized course for personnel involved for perhaps two or three weeks.

2.5.10 Policy advice

In many cases it might be necessary to give high level policy advice on matters relating either to specific projects or industrial policies or industrial project promotion problems. This may on occasions concern only one firm, especially if it is the only major producer in a country. However, it may involve several· in such a case the appropriate counterpart for international support will be the Chamber of Industries as an industrial branch association. Specific policy areas would be broadly similar to those in national policy advice (see 3.1. below) but could include:

- Market analysis

- Specific technology trends

- Industrial organiztion trends

- Company strategy

PROGRAMME 3: DIRECT SUPPORT TO SECTORAL AND PUBLIC ORGANIZATIONS

Besides establishing and strengthening institutions on a permanent basis, organizations can also be supported on a more temporary, project basis in many automation related issues. This chapter reviews direct assistance to all organizations other than public or private firms. Thus it deals with governmental bodies, chambers of commerce, sectoral organizations, cooperative groups of firms. The types of cooperation range from comprehensive financial/investment assistance to consultancy in specific fields.

3.1 SUPPORT TO SECTORAL AND PUBLIC ORGANIZATIONS IN STRATEGY/POLICY FORMULATION AND INFORMATION DIFFUSION[16]

3.1.1 Overview

Governments in some developing countries have adopted a great variety of technology related policy measures in their efforts to industrialize, but in only a few developing countries have industrial and technology policies been clearly formulated and documented. This seems to be particularly true regarding the introduction and diffusion of new technology into the countries. The more coherent policy efforts, which are few anyway, concentrate on the development of the electronics sector and to a lesser extent on the use of computers or on the information technology sector. It is perhaps only in some of the most successful newly industrialized economies - the East Asian NICs and a few Latin American countries - that governments have formulated long range programmes to support technological development.

It is not possible to provide a detailed programme on strategy/policy formulation and information diffusion in the present document, because the specific requirements will be very much dependent on the level of development of the country, the size and structure of industry, and the degree to which the necessary policy framework and institutions are already in place. But it is possible to set out some basic considerations in determining the degree of external support required, and to give some checklists of the areas to be reviewed in the design of assistance in this sphere as well as in its implementation.

This is the purpose of section 3.1. The present part provides a brief summary of the main factors at work in industrial policy, particularly with respect to the needs of developing countries. Part 3.1.2 reviews policy measures, and gives a checklist of the instruments available to governments to meet the objectives in terms of a technology policy implementation. It draws on the analysis of industrial automation so far carried out by UNIDO to present a set of outline recommendations that should be kept ion mind in deciding the scope of the assistance to be given, and should be considered also in the formulation of the final recommendations to government at the conclusions of the technical cooperation project question. The rapidly changing nature of the technology and of industrial policy as a consequence will require such guidelines to be regularly updated. Finally, part 3.1.3 gives an outline of assistance to industrial associations in policy formulation.

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[16] For more detailed information see "Trends in Industrial Automation", UNIDO, PPD.231 (SPEC.), 12 October 1992, Chapter 12.

Technology policy, and the wider sphere of industrial policy, is not an end itself but a means by which governments assist the process of technical improvement at the enterprise level. The renewed emphasis in most countries on the role of the private sector does not in any way diminish the need for either technology or industrial policy, although it affects the choice of instruments to be used by the government in achieving the same end. In particular, the rapid pace of technological change already referred to means that a comprehensive approach at the national level to the enumeration, evaluation and listing of technological choices is not usually practical. Nor could those choices be imposed upon individual enterprises. The specific emphasis of technology policy will be on the creation of a suitable environment for technological progress within the enterprises and sustained support to its continuance and enhancement.

Therefore it is desirable to see technology policy first from the point of view of the enterprises for whom the policy is, after all, being designed. As far as the enterprises are concerned, the most usual problem is that of technology transfer, which may consist of both machinery and equipment as well as skills and experience. The technology has to be appropriate in terms of the size of the domestic market or whatever market is under consideration, as well as appropriate in terms of resource use, etc. A detailed international search for the technologies will be needed, and they will then to be negotiated with the chosen suppliers. The new technology has then to be implemented and absorbed into the existing production system, which will need training and probably incremental innovations as well.

A second stage, and thus a second objective of technology policy, is the management of technical change in production based originally on imported technologies. This will be in the interest both of the enterprise concerned and the broader national interest as well, since it amounts to the establishment of indigenous capabilities. These accumulate through experience, experimentation, conscious efforts and allocation of resources to solve technological problems.

The above summary of the technological development process from the enterprise point of view gives a first indication of the kinds of considerations that are needed at the national level in technology policy. The need is for a systemic technology policy. Since most developing countries have scarce resources, they have to identify the most crucial interventions to make in order that they can benefit from technology gains that result from a more efficient economic and policy framework and some key institutional developments. These have to be achieved at the lowest cost practicable, in terms of investment, administrative requirements, staff and infrastructure.

The main factors behind systemic technology policy measures are information flow, technical content and institutional networking. This kind of approach differs from more conventional policy formulation strategies in the sense that it utilizes the synergistic links between sectors. It is a system approach instead of one that relies on linear causal relations.

The following table provides a checklist of policy measures used in different countries to facilitate technological development. The appropriateness of these measures in any particular case depends largely on the current technological level of the country, existing institutional arrangements and their flexibility, and on the internal capacity to implement such policies.

Table 9. Checklist of technology and policy measures

MEASURES	EXAMPLES
Procurement	Central and local government purchases and contracts, public corporations, R&D contracts, prototype purchases, setting design criteria, choice of priority for technologies.
International trade	Trade agreements, technology acquisition agreements, tariffs, foreign exchange regulations, export compensation, import subsidies, licensing.
Public enterprise	Innovation by publicly owned industries, setting up of new industries, pioneering use of new techniques by public corporations, participating in private enterprises.
Scientific and technical	Research laboratories, support of research associations, learned societies, professional associations, research grants.
Education	General education, universities, technical education, retraining.
Information	Information networks and centres, libraries, advisory and consulting services, databases, technology monitoring, liaison services, public awareness.
Financial	Grants, loans, subsidies, financial sharing arrangements, venture capital, provision of equipment, buildings or services, loan guarantees, duty and customs remissions, export credits.
Taxation	Company, personal, indirect and payroll taxation, tax allowances, tax exemption for private foundations.
Legal and regulatory	Patents, utility models, plant breeders rights, regulatory environmental and health regulations, contractual arrangements, conventions, inspectorates, monopoly regulations.
Political	Planning, regional policies, honours or awards for innovation, encouragement of merges or consortia, public consultation, creation of new institutions, setting up of research funds, initiating legal reforms.
Public services	Purchases, maintenance, supervision and innovation in health service, public building, construction, transport, telecommunications, infrastructure.
External relations	External aid, technical assistance, local and external training.
Internal relations	Sales organizations, trade and diplomatic missions (science and technology attaches), technical cooperations, research representatives.

The above checklist could be used for the following purposes:

- Terms of reference for the policy analysis to be undertaken;
- Determining the composition of inter-departmental committees for government policy formulation;
- Framework agenda for government/industry consultations;
- Branch-level industry association policy analysis;
- Compilation of national programme of action, including policy measures agreed with industry;
- Determination of detailed policy analysis and support package with external assistance.

In addition, certain themes should be emphasized, based on the imperatives of change at the international level and the need for developing countries to respond. These themes include the following:

- more appropriate production of hardware and software,
- better management capabilities and techniques,
- expanded research and technological capabilities,
- innovative ways of increasing labour productivity,
- systematic attempts to enter new non-domestic markets with higher quality products packaged more attractively,
- attempts to reduce comparative transport disadvantages,
- the provision or extension of export credit guarantees and facilities to minimize foreign-exchange risks,
- new mechanisms for policy dialogue.

It should also be noted that certain international experiences of industrial policy need to be reflected in the national policy analysis. Among these, the following propositions should be assessed for their relevance and consequent implications for the formulation of industrial policy in the country concerned:

- factors other than price play a major role in determining the extreme variations in efficiency occurring within different industrial subsectors. In particular the role of management, machine design and engineering skills play a critical role in explaining these differences;
- sustained manufactured exports require far more than short-run cost advantages;
- management and machinery choice questions are vital to the creation of viable industries;
- sheltered regional markets can assist the drive to create efficient manufacturing units;

- the development of manufacturing depends critically upon the presence and promotion of an adequate base of domestic skills;

- sustained import substitution and the development of linkages between subsectors of manufacturing and between manufacturing and other productive sectors are unlikely to be developed within recourse to specific incentives and industrial promotion activities that need at least medium-term financing;

- a liberal trade regime is not a sufficient condition for efficient manufacturing production.

3.1.2 Policy guidelines

Building up a long term technology policy is by no means an easy task. The creation of a more technology driven development path has to be started from an analysis of targets, possibilities and resources available, This is always a country specific task. But some general ideas on the possible measures to be taken can be drawn from the policies adopted in the industrialized countries and the experiences of long term policy built up in Japan and the East Asian NICs. Therefore, in the formulation of policy recommendations for industrial automation, these experiences from other countries should be tested against the realities and requirements of the country in question. In particular, the following recommendations should be considered:

- There is a need to reorganize a variety of public technology policy institutions. They should deal with tasks more relevant to local economic and technological development and this should be done in more intense cooperation with individual firms and other economic actors. This implies more cooperation between universities, research institutes and firms. Common projects with concrete development targets where all types of institutions are involved are often the best form of cooperation. It is also important that all participating organizations have a stake in the project, and thus expect to benefit from it.

- There is a specific need to spread information on the use and possibilities of new technologies. This could be done through, for example, establishing specific 'information technology centres' with differing targets, e.g., CAD centres. There are many possible alternative ways to organize this kind of centre, but it is important that they are in close contact and co-operation with educational and training institutes as well as with firms.

- Companies need direct assistance in getting information on production technology developments and in making technology acquisition decisions. This could be arranged for example through sectoral research institutes, branch organizations or parastatal holding companies, by employing personnel specialized in information gathering and in the creation of links with sources of technological information abroad. The specialists should carry out contract tasks for individual firms, help them both in creating contacts with technology suppliers and in contractual issues.

- Similar assistance is needed by firms in the areas of technology assimilation and adoption. In this case, however, the need is for highly specialized knowledge on production technologies. The need is also for long term support, which must begin

well before the actual implementation of new technologies and must continue until the new systems have been totally incorporated into the everyday activities of the firm.

- General awareness programmes on the effects and possibilities of technological development are needed. They should be associated with an open and wide public discussion of the themes of technological development.

- Companies also need more direct financial assistance in technology acquisition. This means suitable regulations on foreign currency in production technology matters. New production technologies are the means to make the economy more effective and productive: these create new possibilities for economic growth and increased exports and the foreign currency requirements have to be seen in this light. It is not only a question of easier access to foreign currency for buying new production machinery: the need to make customs procedures less complicated, less bureaucratic, and faster is just as important.

- For capability building it is important that local firms be deeply involved in every technology transfer case, even when foreign donors are completely responsible for the process. Technologies imported should be 'appropriate' in at least three senses: they should fit to the existing production processes in the recipient organization, they should raise the technological level of the organization and serve as a basis for capability building, learning and further technological development, and, third, they should support the macro level national development targets. The last consideration may often imply, for example, a target of diminishing the variety of machine types and makes in the country.

3.1.3 Policy formulation in an industrial association

The assistance should include three parts:

- A **seminar** on automation and its effects in the specific industry.
- **Visits** to developed country companies and policy organizations for staff who are to deal with policy.
- **Consultant** services to assist the organization in the actual policy formulation.

Seminar: The first part of the assistance is the organization of an introductory seminar on automation and its effects in the specific industry. The main lines of the seminar programme could be the following:

> **Target group/participants:** personnel who will work with automation policy in the association, representatives from member companies, local researchers on the sector -- if they exist -- and representatives of governmental bodies responsible for the sector.
> **Duration:** Three days
> **Programme:**
>
> **First day:** Prepared presentations by donor agencies, researchers and industrialists from both developed countries and developing countries that have more experience on automation in the sector. Discussion

relating the problems in the country's industry to the experience abroad.
Second day: Presentations by local industrialists, reviewed by foreign participants. Visits to local companies. Discussion of the presentations and visits, and also review of the discussions of the previous day.
Third day: Team work to produce outlines for the automation policy of the association.

Visits abroad: The second stage is a programme of visits to developed country companies and policy organizations for the association's personnel who deal with policy.

Participants: Personnel who will work with automation policy in the association. At least two and not more then four persons.
Duration: Between one and three weeks.
Programme: For each of the visited countries (recommended maximum of three):

First day: Prepared presentations by the local representatives on their actual policy in the specific sector. Presentation of the actual situation of the industrial sector in the developing country.
Second day: Visits to local leading companies and research centres active in the specific field. This could be extended to one or two days more, according to the local situation.
Third day: Discussion relating the problems in the developing country's industry to the local experience. Team work to produce outlines for the automation policy of the association.

Consultancy: The next stage is to assist the organization in actual policy formulation. In doing this, the association will probably need support in drafting the policy. This could be done with the help of one international expert for at least one month and not more than six months.

3.2 LINKAGE/NETWORK CREATION AND THE ESTABLISHMENT OF LOGISTICAL CONNECTIONS BETWEEN COMPANIES

Governmental and other public institutions are not the only ones who spread information on new technologies. Industrial and employer associations, chambers of commerce and other local business organizations can have an important role to play in supporting technological development. In some cases, international assistance may be more effective, if it is allocated to this kind of organization rather than to governmental bodies.

Networks and strategic alliances are a central consideration of automation strategy.[17]

Shop floor level changes, such as implementation of new work organizations and introduction of advanced automation, are only the one part in business strategy of flexible specialization. The other part consists of changes in firm and business organization. The flexible production model involves a trend towards more decentralized and informal

[17] See "Choices in Industrial Automation", UNIDO, PPD.... (forthcoming), chapter 3.

governance structures. This includes both changes in the enterprise internal organization renewals and new linkages to outside organizations.

The main trend is twofold:

- Splitting up structures based on rigid internal hierarchies and strict control from upper levels towards more autonomous and independent units.

- Moving from anonymous market relations based on money transaction towards more cooperative, long time development relations based to a growing extent on confidence and mutual dependency.

In large concerns this has meant a radical decentralization of power and breaking up the existing organizational hierarchies. The main aims of these changes are:

- to gain more flexibility at the enterprise level in order to reallocate resources rapidly from one area to another;

- to create a co-operative organization of small independent units that are all able to react rapidly to market and technology changes;

- to motivate management and personnel in the units to more innovative and committed activity.

Even more important are networks between firms and concerns. Networks are an outcome of a trend, where firms - instead of horizontal diversification or vertical integration - concentrate on their core business where their key skills are. Supportive functions and even parts of the main activities are to a growing extent ousted from the firm and acquired through various contracts and other arrangements from outside sources. Through these contracts' enterprises create a network of strategic alliances with other companies.

For small firms, linkages and creating networking relations is even more important than for large concerns. Even a technologically competent small firm alone is powerless without the necessary connections and linkages to all outside interfaces. This is especially true for companies in technologically developed sectors, where small firm resources and internal skills are inadequate even for many vital activities.

A firm thinking about extensive investments in automation based on flexible specialization strategy also has to rethink its outside relations. Flexibility only within the company itself is not enough. In interfirm relations, flexible specialization involves a shift from market governed relations to more long standing, cooperative relations, based on mutual contracts.

3.2.1 Networking local firms with foreign technology suppliers

A local chamber of commerce, an industrial association can act as a networking agent between local firms and foreign technology suppliers, research institutes and industrial associations (chambers of commerce etc.). To strengthen this activity, international support can help the institution in choosing and creating the linkages to the foreign parties that are suitable and willing to cooperate.

The assistance could consist of three parts:

- Assistance in the study of the local industrial structure to establish the specific areas where networking would be necessary and helpful. This could be done through the assistance of one expert for one month.

- Assistance in establishing links with different suppliers. This could be organized with the support of one expert and representatives of commerce chambers from developed countries to find the possible counterparts in developed countries. After this step, representatives of the sectoral organizations and/or chambers of commerce and/or others should be supported in the formal aspects of the bilateral contracts.

- Assistance in training the personnel to keep up the linkages and inform local firms about the connections. This could be done through a specialization course of two to three weeks for the personnel involved, followed by a seminar to inform the local firms about the existing connections and the ways and means of accessing them.

3.2.2 Creation of international information linkages

To be able to diffuse information, the institution also has to have access to other regular sources of information. This includes linkages to the main data banks in their field of activity, good telecommunication connections abroad and a continuous flow of the most important business periodicals, magazines, journals and research publication series in their sector. International support could include the setting up of these information sources, as well as aiding the institution in library development and informatic questions.[18]

The assistance could consist of three parts:

- Assistance in selection of the required hardware and software as well as the means of access to the required databases. This could be done through the assistance of one expert for two weeks.
- Assistance in selecting and establishing the connection with different databases all over the world and for the preparation and set-up of the database, up to the operational stage. This could be organized with the support of one expert for two months.
- Assistance in training the personnel to keep up the connections, maintain the database and manage the access to information for the local industries. This could be done through a specialization course during two to three weeks for the personnel involved.

3.2.3 Creation of information linkages between local companies, universities and research centres

Typically, companies in developing countries are not large, nor do they have many staff available who are skilled enough to work in automation-related fields. This applies

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[18] UNIDO already has extensive activities of this kind through the operation of INTIB, the Industrial and Technological Information Bank, and the networks established under this heading.

whether the work is in the field of analysis of requirements, negotiation of acquisition, or implementation. Financial resources will also be limited, and it will be difficult to meet requirements in terms of equipment, international information services, study tours, etc. Resource sharing between companies, and closer links with local universities, may be able to resolve some of these difficulties.

One structure to further is conceptualized as an Industry Club (see Box 1.) International support projects can be designed in consultation with local enterprises, by identifying the specifications that cannot be met locally, that cannot be substituted for, and that are essential for dealing with the particular set of problems that is faced in the country concerned. The descriptions of the Industry Club is therefore a checklist for identifying the external inputs needed to help local enterprises share their resources for implementing industrial automation strategies.

3.2.4 Creating or strengthening the infrastructure for diffusing technology information

In diffusing technology information to the member organizations, the local institution could use seminars, conferences and also more informal gatherings. Relatively short meetings (half-day seminars) are often necessary. Small firms especially, even in developed countries, do not usually have personnel specialized in technology development questions. These are usually the responsibility of the managing director, who has very limited time to spend on meetings not directly related to business or on reading reports. A short meeting, however, may be enough to encourage their interest in manufacturing technology development.

International support may assist the institution in:

- Planning and arranging the meetings (support of one expert for one month, to prepare the type, schedule, contents and desired participants for each meeting)
- Transferring experiences from corresponding activities in developed countries (support of one expert for two weeks).
- Building up the necessary infrastructure (see Box 2, Seminar facilities).

3.3 SUPPORT TO RESEARCH INSTITUTIONS IN PROJECT FORMULATION

This covers direct support to local/regional/national and sectoral research organizations in their work on the effects and the opportunities created by industrial automation. It could include, for instance, local studies of firm productivity, capacity utilization rates, automation support networks, etc.

In the long run, technological development also requires support from institutionalized research and development. This is especially true for creating new technology based products, but even a wider diffusion of advanced production technologies needs backing from domestic research. Implementing automation is connected to a wide variety of problems to which there are no "on the shelf" solutions supplied. In addition, adapting of new production processes and products to each other in a new environment and further development of locally fitting automation solutions also needs research and development support.

Support to a research institution in developing countries in applications of automation related technologies can take forms quite similar to those of support to educational institutions and technology centers. The first issue should be the determination of the requirements of the local industry:

- Is there a need to expand the activities of the institute?
- What are the problems that the institute should address?
- Is there enough demand for the work done in it, and is the demand likely to grow?
- What should be the main focus of the institute, and what are the basic targets?

To promote automation, the most important areas of institutionalized research are various fields of technical research, e.g. research on mechanical and electric engineering, mechatronics, and other direct technological studies on automation technologies.

The target of a technical research institute is to produce information for the basic understanding and developing of the technologies to be used. Research also produces the highly skilled engineering specialists who are capable to assist companies in technical problems and in training technical personnel. Research and development institutions should, in a developing country context, also be able to help other organizations in solving their technical problems. In this respect, the activities of a technical research center in a developing country often come close to those of a technology centre.

There is also the pressing need in developing countries to strengthen research on organizational and economic consequences of automation, as well as on technology policy options. These fields including investigating the skills needed, the training and education requirements, and the economic and organizational as well as business strategy effects. This kind of research is necessary to assess the effects and consequences of further technological development. The basic studies may be done with foreign support, but in the long run domestic research to support decision making is indispensable.

Support to research institutions may consist of:

- Consultancy in restructuring the activities of the institute.
- Assistance in studies on organizational and economic consequences of the introduction of new automation technologies in the local industrial society.
- Direct financial support.
- Establishing or strengthening information linkages.
- Establishing or strengthening cooperation with other research institutes in developing/developed countries.

NOTE: This kind of assistance was already discussed in more detail in subprogramme 1.3, Establishment/strengthening of research institutes.

3.3.1 Restructuring the activities of the institute

This project could be seen as a whole, but in most cases not all of the activities would be necessary. The complete programme should include at least the following steps:

- **Studying the actual organization and available resources of the institute and determining the position of the ongoing research work inside the international research**

This could be done through the assistance of one expert for at least three weeks, and not more than two months, to prepare a report on the actual situation with some proposals for a new structure and clear definitions of the level of research in the different areas. The work could include:

  - Visiting the different laboratories to determine the existing resources, how they are being used, and for what purposes.

  - Individual discussions with researchers to obtain an overview of the role of functioning of the institute and to detect structural problems.

  - Individual discussions with industry and government, to obtain information on the degree of integration of the centre in the economy.

- **Assessing research requirements**

This could be done through the assistance of one expert for at least one month, and not more than three months. On the basis of the report prepared in the first step, a meeting should be arranged with representatives of sectoral institutions and leading companies, to discuss their research requirements. The consultant should also assist in the selection of the possible research fields, determining if it would make sense to undertake it locally, or to have a joint venture with a developed country research centre, or to have a direct link between the industry and a developed country research institution.

- **Initiation of a new research field**

This will include determination and selection of staff and equipment, medium- and long-term planning, etc. Depending on the field, this should be done with the assistance of one or more experts, for a period that could be between a couple of months to a couple of years. In some cases the assistance could be carried out through supplementing and/or training the personnel in selected research areas.

- **Training personnel for optimal use of the existing equipment**

For selected areas, and based on previous reports, this would mean assistance to the institution in the organization of seminars and training courses. The external resources needed would vary with the subject and the capabilities of the institute.

- **Selecting and supplying the institute with new equipment and training in its use**

Depending on the research are this could be done with the assistance of one expert for a period ranging between one week and two months. The assistance could include a seminar with presentation of possible equipment, by representatives of the supplying companies.

3.3.2 Study of organizational and economic consequences of the introduction of new automation technologies in the local industrial society

The assistance should include two parts:

- A **seminar** on industrial automation and its effects on organizational and economic structures. The main features of the seminar could be the following:
  - **Target group/participants:** Representatives from companies, local researchers on the sector and representatives of governmental bodies responsible for the sector.
  - **Duration:** Three days.
  - **First day:** Prepared presentations by donor agencies, researchers and industrialists from both developed countries, and developing countries with more experience on the introduction of new automation technologies. discussion relating the social problems in the country's industry to the experience abroad.
  - **Second day:** Presentations by the local industrialist and governmental representatives about the social problems they have found in the past by the introduction of other technologies. Visits to local companies.
  - **Third day:** Teamwork to produce outlines of the required studies to be done.

- **Consultant** services to assist the organization in the formulation of studies to be carried out. This could be done with the help of one international expert for at least one month and not more than six months.

3.3.3 Direct financial support

This could be done in many different ways. The selection of the type of financial aid should be based upon:

- a study of the different possibilities and their implications;
- a mechanism to allow the monitoring and the evaluation of the work to be carried out.

3.3.4 Establishing or strengthening information linkages

Some ways in which developing country research institutes could be helped in reaching information sources include the following:

- Linking the research institute to the main data banks in their field of activity;
- Strengthening other telecommunication contacts between the institute and developed countries institutions, e.g. through acquisition of telefax or electronic mail appliances to the institute;
- Supplying the institute with a continuous flow of the most important periodicals, magazines, journals and research publication series in their field of activity;
- Supporting the establishment of a national/regional productivity data base centre;
- Supporting the establishment of a technology data base centre;

- Supporting the institute in the publication of research work in international journals.

These issues - telecommunication linkages abroad, supply of published information and links to data banks - are among the basic conditions for any research institute to function. Their status should be checked and defects remedied as a first task in any support programme aiming to strengthen a research institute.

For more details about the hardware requirements of the local data bank see Box 1.

3.3.5 Establishing or strengthening cooperation with other research institutes in developing/developed countries

For a technological research institute in a developing country, regular contacts with corresponding institutes in developed countries are quite indispensable. They serve both as a regular channel for transferring scientific information, and as a means of upgrading the skills of researchers. A fruitful form of international development assistance to strengthen a research and development institute in a developing country could consist of creating, supporting and financing continuous cooperation between the institute in question and a developed country research institute. The cooperation programme includes:

- Sending perhaps two or three researchers each year to the develcped country institute to work in research programmes relevant to the sender country.

- Organizing shorter working visits (of one to three months) for five to ten other researchers to the developed institute.

- Sending perhaps two or three researchers to the developing country institute from the develcped country institute, to work in local development projects previously determined as cooperative research areas where the developed country institute is expected to help the developing country institute.

- Arranging shorter term expert visits from the developed country to the developing country institute to help especially in supervising and solving critical problems in local research and development projects.

- Arranging cooperative seminars between the two institutes on technical themes of current interest.

If the institutes are connected - or in close collaboration - with (technical) universities, the cooperation should be expanded to doctoral courses. This might include sending each year between five and ten doctoral students to the developed country institute. Their dissertation work should be on topics relevant to domestic technological development projects. As well as this, the exchange programme between the two institutes should include encouraging and supporting (financially etc.) developed country doctoral students to choose research areas relevant to the developing country partner.

BOX 1. THE INDUSTRY CLUB

The Industry club

The Industry club should have some or all of the following facilities, although at least the first and the second one should be included.

(I) A centralized database with information or, inter alia:

- Ongoing and pipeline projects, including status of the project (beginning date, planned steps, deadline), type of the project (research, study, industrial, application, national or international, etc.), participants, etc;
- Publications available, local or remote;
- Consultancy services offered and asked;
- Planned conference and meetings.

(III) Seminar facilities, for the diffusion of information on actual or future activities, or for preparing the ground for long term projects of the Industry club as well for invited speakers in specific areas. The areas to be covered should include not only technological ones but also organizational and managerial ones. The activities and courses should include:

- General introduction to new technologies and/or organizational changes;
- Specific courses offered by vendors on the use of their products;
- Specially adapted preparatory courses for long term projects.

Some examples of different type of training programmes:

- **Company level training:** This would range from separate automation related courses to employees in different tasks (e.g. training maintenance people to new machinery, management to automation strategies) to comprehensive training for all the personnel e.g. in association with a major automation related investment.

- **Inter-company, sectoral and cross-sectoral training:** Examples would include:

  - sectoral (a course on the possibilities of CAD in clothing for people in various positions in companies);
  - functional (a training on automation for people in maintenance, management, production etc. positions);
  - thematic (e.g. automation strategies, use of CAD, using computers in production control, organization for quality control on inter sectoral/non specified level).

- **Teacher/trainer training programmes:** Specific courses to train trainees and teachers in permanent educational institutions on issues relevant in implementing automation and future training in the country.

- **General training/awareness/information diffusion programmes:** More open arrangements with the target of diffusing information and raising the level of awareness in matters related to automation, e.g. seminars, conferences, publicity campaigns, discussions and "development days" on various issues.

continued

BOX 1. THE INDUSTRY CLUB (continued)

(III) Laboratories for selected technologies:

- Demonstration of features of specific technologies. The facilities used would include those donated by vendors interested in the introduction of their product, existing facilities in the industry, and existing facilities in research centres or universities

- Consultancy:
  - to allow the members of the club to share hardware facilities which are not continuously required. (e.g. simulation of factory layout, off-line generation of NCMTs from CAD);
  - to carry out development and testing before buying specific equipment (e.g. feasibility of the use of a robot for a specify task);
  - to train workers on the use of hardware and software;
  - to give technical and logistical support in the machine selecting phase as well as in the post-installation phase.

(IV) Financial and logistical support:

- to give information on current financing possibilities and support to industry in the necessary formal steps;
- to give support in the planning phase of a project;
- to give support in subcontracting activities with external consultants or companies.

(V) Database

The database should be based on a computer with or without (depending of the type of access required) remote access possibilities.

Access to the database

There will be two kinds of interaction possibilities with the database, the request of information and the introducing of new information. With regard to the latter, the best way to assure a real database where only usable information is included will is to do it in a centralized way. This means a system manager will be responsible for introducing the data. This is specially important in the introduction of proposed projects where the ideas should be discussed in relation to existing objectives and where the introduction of wrong, confusing or unnecessary information should be avoided (e.g. introduction of a vague idea as a existing project, offers of consultancy services without enough background, etc.).

For requesting information from the database, there should be one or more of the following possibilities according to the facilities available (bad telephone lines would make remote access very difficult).

Remote

- Remote interactive access: through datex-p or similar facilities, using selected keywords to access the database on-line using a given format. The procedure would be to remote log-in the database using a specified password and to ask the required information in an interactive way.

continued

BOX 1. THE INDUSTRY CLUB (continued)

- Remote off-line access: through Electronic Mail facilities, using selected keywords to access the database using a given format. The procedure would be to send a message with the required information to the system manager of the database. This message would enter into a waiting queue established by the manager and the answer will be send back to the sender.

Local on-line access. The local facilities should include a interactive terminal with or without a system manager to allow local requests of information.

Local availability at each industry

- Industry based computer facility. If the industry has a local computer facility, the database should be supplied regularly in the form of a diskette. The information should be available on specific areas or as a whole, to allow different kinds of participation. To allow this possibility the database should be maintained in a cheap and well known software package or at least compatible with it.

- Monthly or weekly report. If the industry has no local computer facility the information should be sent in form of a report. Again this report could be a general one on all the information contained in the database, or it could cover only defined areas and be perhaps ordered in a specifically required manner.

Required hardware

For all access possibilities except remote interactive access, it will be enough to use a personal computer type with the following characteristics:

80486/25 Mhz Microprocessor
4MB of main memory or more
100 MB Hard disk or greater
2 Serial and 2 parallel ports
1 disk unit 3.5" high density
1 disk unit 5.25" high density
VGA Monitor
Mouse
Modem for remote access possibilities and communication with other databases
Some kind of fast backup possibility would be desirable
A full page digitizer would be desirable
Laser printer or at least a fast 24 pin matrix printer

Required software

- Database software. A well known and not-expensive one. (A combined database, capable of storing text and graphics could also be considered, but only if it is compatible with a wide extended text database.
- CAD System. A 2.5 or 3 D software package would be desirable in order to maintain also graphic information necessary for the projects.

Required personnel

System manager, with an engineering background.

BOX 2. SEMINAR FACILITIES

Seminar facilities

Building

- Full equipped local seminar room for at least 20 participants. Possibilities of larger rooms in other sites (e.g. university) should be studied.

Equipment

- Overhead projector
- Slides projector
- Clip board and black board
- Personal computer for the preparation of seminar documents and overheads
    - 80386/16 Mhz Microprocessor
    - 2MB of main memory or more
    - 40 MB Hard disk or greater
    - 2 Serial and 1 parallel ports
    - 1 disk unit 3.5" high density
    - 1 disk unit 5.25" high density
    - VGA Monitor
    - Mouse
    - Laser printer or at least 24 pin matrix printer (could be shared with the database computer)
    - Printer for overheads

Software requirements

- Painting programme for the preparation of overheads
- Word processing programme for the preparation of seminar documents

Required personnel

- Part time secretary
- Seminars manager, part time, for following activities:
- Co-ordination of seminars and meetings
- Preparation and given of specific courses

Laboratories for selected technologies

The facilities and personal requirements would depend on the installed technologies. It would be desirable to use existing facilities and personal from universities or research centres.

ANNEX

ENTERPRISE AUTOMATION QUESTIONNAIRE

1. Name of Firm, address and telephone number:

2. Respondent and job title:

3. Industrial sector and product type(s):

4. Type of production (tick): Unit ☐ Batch ☐ Mass ☐

5. Average batch size (approximate): (give units)

6a. How many different products do you produce (appr.): .....

6b. What is your yearly output (units): .....

6c. What is your yearly capacity (units): .....

7. Company size (approximate):

	1986	1991
Turnover	.....	.....
Number of employees	.....	.....

8. Labour costs (% of total costs-approximate):

9. Management structures:

Number of layers: .....

Single or multi functions: Single ☐ Multi ☐

10. Is change based on "Project Champions" or team working?

Project ☐ Team ☐

11. What is the main impetus for change?
(Rank on the following scale):

	Crucial	*Very important*	*Important*	*Useful*	*Not important*
Reducing costs of material inputs	☐	☐	☐	☐	☐
Reducing cost of labour	☐	☐	☐	☐	☐
Reducing skill requirements	☐	☐	☐	☐	☐
Improving product design	☐	☐	☐	☐	☐
Reducing cost of design	☐	☐	☐	☐	☐
Reducing times for design	☐	☐	☐	☐	☐
Increased product standardization	☐	☐	☐	☐	☐
Reduced door to door times	☐	☐	☐	☐	☐

12. Do you wish to automate production processes?

Yes ☐ No ☐

13. Why do you wish to automate?

(A)	Improve product quality	☐
(B)	Extend product range	☐
(C)	Improve your flexibility to respond to customer requirements	☐
(D)	Reduce labour costs	☐
(E)	Reduce capital costs	☐
(F)	Reduce material costs	☐

14. How do you intend to achieve your objectives?

15. Who decides on product or process changes?

16. What links do you have?

(A) With customers:

(1) ☐ In tailoring products
(2) ☐ In exchange of ideas for changes
(3) ☐ Do you have CAD based links
(4) ☐ Other
.....

(B) Economic or Technical links?

(1) ☐ Time scale of orders
(2) ☐ CAD/CAM links
(3) ☐ Investment in supplier companies
(4) ☐ Using own market power
☐ (i) on materials
☐ (ii) on equipment
(5) ☐ Improving product quality
(6) ☐ Improving delivery times
(7) ☐ Reducing overall costs

BACKGROUND

17A. Is the firm an independent one or part of a group? Independent ☐ Group ☐

17B. If part of a group, what kind is this?

(1) A commercial national group ☐
(2) A parastatal group ☐
(3) A commercial international group ☐
(4) Other
.....

18A. Is there a national research association dealing with your industrial interest?

Yes ☐ No ☐

If not, would one be helpful for you?

.....

If yes, please give name, address, telephone and fax numbers:

18B. **Are there trade councils established in your country to assist you in your business matters?**

Yes ☐ No ☐

18C. **Is there a governmental-run institute to deal with your industry interests?**

Yes ☐ No ☐

18D. **Is your company unionized?**

Yes ☐ No ☐

18E. **Do you have the complete right to hire and fire or are there restrictions?**

Yes ☐ No ☐
If the latter, what are these?

.....

18F. **What are your social costs of employment, e.g. wages, insurance, employee taxes?**

.....

18G. **What maintenance facilities exist?**

Internal resource	☐
Local Services	☐
Locally based supplies	☐
Spare part availability	☐

PRODUCTS AND PROCESSES

19. **What production equipment do you use?** (Brief description)

20. **What types of automation?**

21. **Do you use, for example?**

(A)	Automated guided vehicles	☐
(B)	Industrial robots	☐
(C)	Host computers	☐

22. What area do you introduce new technology into?

(A)	☐	Storage
(B)	☐	Handling
(C)	☐	System Feeding
(D)	☐	System tooling
(E)	☐	Control systems
(F)	☐	Inspections systems

23. Have the benefits been calculated?

24. What impacts have been felt?

		Problems	
		Expected	*Actual*
(A)	Anticipated production targets	☐	☐
(B)	Financially justifiable investment	☐	☐
(C)	Meeting financial targets	☐	☐
(D)	Industrial relations	☐	☐
(E)	Training/re-training	☐	☐
(F)	Workforce acceptance	☐	☐
(G)	Accepted by the work force	☐	☐

25. Who designed/installed your automation?

		Designed	*Installed*
(A)	In-house	☐	☐
(B)	Consultants	☐	☐
(C)	Hardware companies	☐	☐
(D)	Software companies	☐	☐

26. What design facilities exist?

(A)	Draughting	.....
(B)	CAD (2-D, 3-D)	.....

27. Main barrier to automation (Rank)

(A)	Cost	☐
(B)	Lack of expertise	☐
(C)	Too complicated	☐
(D)	Lack of local skills	☐

28. What are your main automation problems (Rank)?

(A)	The hardware	☐
(B)	The software	☐
(C)	Organizational changes	☐
(D)	Problems with suppliers	☐
(E)	Lack of compatibility	☐
(F)	Lack of finance	☐
(G)	Lack of skilled people	☐
(H)	Other	

29. What impacts have you felt or do you expect on the following?

		Felt	*Expect*
(A)	Lead times	☐	☐
(B)	Work in progress	☐	☐
(C)	Equipment utilisation rates	☐	☐
(D)	Employment	☐	☐
(E)	Stock turnover	☐	☐
(F)	Other		

30. Do you now use, or expect to use:

		Now used	*Expected*
(A)	More skilled workers	☐	☐
(B)	More graduates	☐	☐
(C)	More unskilled workers	☐	☐

31. If you use automated technologies, were there any benefits you did not expect, e.g. improved orders, new customers, improved quality, improved industrial relations, etc.?

32. Do you now produce, or expect to produce, a more limited number of products, or more?

		Now produced	*Expected*
(A)	More limited	☐	☐
(B)	Wider range	☐	☐

33. Do you use the following automation equipment and related techniques:

(A) *In Manufacturing*

FMS or FMC	Yes ☐	No ☐
AGVs	Yes ☐	No ☐
TQC	Yes ☐	No ☐
Robots	Yes ☐	No ☐
Others		

33. *(B) In Design*

CAD	Yes ☐	No ☐
SBQ	Yes ☐	No ☐
Others		

(C) In Management

MRP	Yes ☐	No ☐
JIT	Yes ☐	No ☐
Others		

34. How close are your relations with your supplies/customers?

(A) Suppliers (Rank)?

(1) Price based ___
(2) Quality based ___
(3) CAD linked ___
(4) Representative linked ___
(5) Regular visits/consultation ___
(6) Others

(B) Customers (Rank)?

(1) Price based ___
(2) Quality based ___
(3) CAD linked ___
(4) Representative linked ___
(5) Regular visits/consultation ___
(6) Others

35. How important to you are scale economies of production (Rank)?

36. How important to you are scope economies of production (Rank)?

37. Can you achieve both economies of scale and scope?

Yes ☐ No ☐

38. **What have been, or do you expect to be, the effects of new technology on the following?**

		None	*Slight*	*Significant*
(A)	Management structures	___	___	___
(B)	Management roles	___	___	___
(C)	Organisational structures	___	___	___
(D)	Worker technical ranks	___	___	___
(E)	Training programmes	___	___	___
(F)	Industrial Relations	___	___	___
(G)	Shift work patterns	___	___	___
(H)	Relations with suppliers	___	___	___
(I)	Others	___	___	___

39. **Does the company use Q.C.circles?**
Yes ☐ No ☐

40. **What are the benefits of this?**

(A)	Better quality	Yes ☐	No ☐
(B)	Improved worker relations	Yes ☐	No ☐
(C)	Other _____	Yes ☐	No ☐

41. **Does the company use the JIT system?**

Yes ☐ No ☐

42. **Do you have preferential suppliers rather than base purchases on cost alone?**

Yes ☐ No ☐

43. **Have you introduced MRP systems?**

Yes ☐ No ☐

44A. **Are you using automation processes, e.g. NCMTs, Robots?**
New ☐ Second-hand ☐

44B. **If so, were these purchases as new or second hand?**
Yes ☐ No ☐

44C. **How long have you been using such technologies?**

44D. **If not using such technologies, do you plan to do so in the near future?**
Yes ☐ No ☐

44E. If using such technologies, on what processes are they used?

44F. List the types of technologies used:

CAD	___
Grading/Marking	___
Knitting MICs	___
Sewing Systems	___
Prod. Control	___
CAD/CAM	___
NC Equipment	___
Robots	___
Test & Inspection	___
FMS or FMC	___
Materials Handling	___
Warehousing/ Storage	___
Communications	___
Other	___

44G. Who developed the technology you have installed?

Own Firm	___
In Collaboration	___
Consultants	___
Equip. Supplier	___
Research Institute	___
University	___
Other	___

44H. What have proved to be the biggest problem areas in using such technology?

Lack of skilled personnel	___
Tech./Maintenance	___
Shopfloor	___
Management	___
High costs	___
Lack of finance	___
Technical Sophistication	___
Organizational	___

45. Are you able to obtain spare parts and materials without significant breaks in production? If not what are the barriers, e.g. customs restrictions, government policy?

46. Are you able to establish/maintain close contacts with foreign companies/institutes for information purposes?

47. Do you have your own design facilities? If so, how are they staffed?

Own Nationals ☐
Foreign Nationals ☐
Use Consultants ☐

HUMAN RESOURCES AND SKILLS

48. How have new processes affected human resources needs?

(A) Numbers of human resources .....
(B) Human resource types .....

49. Any skill shortages?

(A) Graduate level _____
(B) Systems People _____
(C) Multi-Disciplinary _____
(D) Maintenance _____
(E) Others _____

Are these: (A) A major problem _____
(B) An Irritant _____

50. Labour Changes (Job Creation or Job Losses):

(A) Direct Labour _____
(B) Indirect Labour _____
(C) Overall _____
(D) Labour Costs _____

51. Graduate Employment (numbers):

(A) Now _____
(B) 5 Years ago _____

52. Graduate Departmental Split:

(A) R&D _____
(B) Systems _____
(C) Production _____
(D) Manufacturing _____
(E) Other _____

53. Changing Work Patterns:
(Alternatives in work organization design and the reasons for the adoption of those in-house)

54. Changes in skill integration:

55. Integration of direct and indirect occupations:

56. Skill level changes:

57. Are there new skills needed?

		Yes	No
Production			
	Controllers	☐	☐
	Chasers	☐	☐
	.....		
	.....		
Maintenance			
	Electrical	☐	☐
	Mechanical	☐	☐
	Hydraulic	☐	☐
	.....		
	.....		
Setters-Operators			
	Programming/Maintenance	☐	☐
	.....		
	.....		

58. Trade Union or Employee Resistance:

- Trade Union Yes ☐ No ☐
- Employee Yes ☐ No ☐

59. Managerial Reluctance to Change:

Yes ☐ No ☐

60. Adoption of J.I.T. or M.R.P.:

(A) J.I.T. Yes ☐ No ☐
(B) M.R.P. Yes ☐ No ☐

.....
.....

61. Adoption of T.Q.C. or Traditional Inspection:

(A) T.Q.C. Yes ☐ No ☐
(B) Inspection Yes ☐ No ☐

.....
.....

62. Management Style Changes resulting from new technology:

63. Devolution of Responsibility to Shopfloor:

64. What change would you expect in numbers employed in 5 years time?

65. What changes would you expect in qualifications in 5 years time?

66. What changes would you like to see in training:

(A) Inside the Firm:

(B) Outside the Firm:

76. **Is there an effective communications network available?**

Yes ☐ No ☐

77. **If there are communication problems, where does this occur?**

1. Telephone _____
2. FAX _____
3. Postal _____
4. Satellite _____

INVESTMENT

78. **What levels of investment have taken place in the last 5 years?**

1987	1988	1989	1990	1991
___	___	___	___	___

79. **How much of this has been in introducing automation? (%)**

1987	1988	1989	1990	1991
___	___	___	___	___

80. **What per cent of investment do you normally devote to training or education?**

81. **What is your normal expectation for the return on your investments?**

82. **Can you give an approximate figure for the level of capital stock per employee?**

83. **Are you aware of government programs which support your investment in new technology?**
What are these?

84. **Have you or do you intend to use these programmes?**
If not, why not?

85. **What government support policies would most help your company?**

86. **Does the government or other parastatal bodies provide any of the following:**

Advisory Services	☐
Demonstration Centres	☐
Research Facilities	☐
Industrial Associations	☐
Information Services	☐