Industrial Promotion and Technology Branch
TRADE CAPACITY BUILDING
WORKING PAPER SERIES 04/05

Establishment of National Capability

Providing Instrumentation Support Services: Case Study

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

INDUSTRIAL PROMOTION AND TECHNOLOGY BRANCH

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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna, 2005

Working paper series on Trade Capacity-Building
Industrial Promotion and Technology Branch

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Executive summary

The limited quantity and large variety of measuring instruments in developing countries cannot provide enough technical work to justify the establishment of the efficient service stations needed by the individual manufacturers. However, the wide variety of the equipment and instruments being used by the various institutions in developing countries limits their capabilities and the capacity to maintain and repair them. The instruments are also a sizeable part of the national wealth. The efficient use of national instrumentation resources is necessary for the viable operation of the existing systems and is also a prerequisite for technical, industrial and economic development.

The safe operation of quality systems is greatly hindered by the poor condition of precision measuring instruments. Thus, there is an urgent and broad need for the establishment of local capability that can provide the needed services on site.

The experience of a local unit in Malawi that can provide instrumentation support services to customers is analysed in this study. In one year, the unit (with one full-time electronic engineer and five part-time scientific operators, engineers and supervisors, all from Malawi) has repaired several precision measuring instruments in the proper order of priority.

The use value of the precision measuring instruments, which were repaired by the local unit in the period from October 2002 to August 2003, was about US$ 130,000. The current value of those instruments, which can solve the measuring tasks mentioned, would be approximately US$ 400,000. This sum neither includes the value of the measurements, which are carried out with the repaired measuring instruments, nor the effects of the measurements or the operation of the repaired instruments on social and economic development.

The first analysis of the costs and expenditure during this period shows that a total income of US$ 9,320 was generated. Total expenditure, which includes the cost of a basic repair tool-kit, salaries, spare parts, transport, allowances and renovation of the workshop, was US$ 4,800. This calculation shows that during the project a surplus of US$ 4,520 was generated. In the next fiscal year, without any outside support, the Malawi Bureau of Standards succeeded in increasing the part of the income from clients from 32 per cent to 69 per cent, which is an important step in the direction of self-sustainability.

Explanatory notes

The description and classification of countries and territories in this publication and the arrangement of the material do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization concerning the legal status of any country, territory, city or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries, or regarding its economic system or degree of development.

In some tables, the designations are intended for statistical convenience and do not, necessarily, express a judgement about the stage reached by a particular country or area in the development process.

Countries are referred to by the names that were in official use at the time the relevant data were collected.

Mention of firm names and commercial products does not imply the endorsement of the United Nations Industrial Development Organization.

The following abbreviations have been used in this publication:

FDI	foreign direct investment
GDP	gross domestic product
GNP	gross national product
ISO	International Organization for Standardization
ISSC	instrumentation support service centre
ISSU	instrumentation support service unit
KEBS	Kenya Bureau of Standards
LDC	least developed country
MBS	Malawi Bureau of Standards
MEESIR	Malawi Electronic Equipment and Scientific Instrument Registry
MSTQ	metrology, standardization, testing and quality management
NEESIR	National Electronic Equipment and Scientific Instruments Register
NIE	National Institute of Electronics (Pakistan)
NUSESA	Network of Users of Scientific Equipment in Eastern and Southern Africa
PTB	Physikalisch-Technische Bundesanstalt (Germany)
QMS	quality management system
QSM	quality standardization and metrology
R and M	repair and maintenance
SADC	Southern African Development Community
SQAM	standardization, quality assurance, accreditation and metrology

SWOT	strengths, weaknesses, opportunities and threats
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organization
WTO	World Trade Organization

I. The conception of the instrumentation support service centre

A. Introduction

Global technological development and the participation of developing countries in international trade are putting increasingly strong emphasis on the operation of quality management systems (QMS), throughout the whole economy (food industry, scientific research, public health services, higher education etc.). In developing countries, these trends have forced the recognition of the importance of the strategic implications of quality for competitive, sustainable and successful industrial development. The build-up of quality infrastructure in national standard bodies, as well as in industry and agriculture, has led to large purchases of more and more sophisticated and expensive measuring and testing instruments without much thought being given to the management, operation, technical background or the technical support services that are necessary for the safe operation of those instruments. The instruments are also a sizeable part of the national wealth. The efficient use of national instrumentation resources is necessary not only for the viable operation of the existing systems, but also for technical, industrial and economic development.

There can be no competitiveness even in a local market if a particular manufacturer cannot claim with any degree of confidence that his products meet the parameters specified in standards. Also the importers and consumers who will be purchasing a product need to know that the particular product is indeed what it purports to be.

All companies that started to operate their quality management according to the International Organization for Standardization (ISO) recommendations on standards and that intend to take part in international trade activity need instrumentation support services based on contracts with local organizations and companies. They need partners that can provide continuous services on a contractual basis for their quality management on preventive maintenance, the calibration of their measuring equipment, consultancy etc. (i.e. instrumentation support services), and in order to be able to carry out reliable, repeatable measurements.

The limited quantity and the large variety of measuring instruments in developing countries cannot provide enough technical work to justify the establishment of the efficient service stations needed by the individual manufacturers. However, the wide variety of the equipment and instruments being used by various institutions in the country limits their capabilities and the capacity to maintain and repair them. The result is that the vast majority of the instruments are either inoperable or cannot measure according to specifications, so the measurements done are not reliable, nor can local qualified services be found to carry out those tasks.

The safe operation of quality systems is strongly hindered by the poor condition of precision measuring instruments. Accordingly, there is an urgent and widespread need for the establishment of local capability that could provide the required services on site.

B. The UNIDO approach

1. Background on the development of the instrumentation support service centre

The safe operation of precision measuring instruments is essential to the performance of quality systems and requires support services; however, in developing countries there is a considerable shortage of such services.

This problem has been analysed by numerous organizations, including the American Association for the Advancement of Science, which summarized the problems encountered in maintaining and repairing

measuring instruments in developing countries in a feasibility study in July 1988. In the study several solutions were considered:

(a) *Training approach*: It is assumed that training is the solution to the equipment problem;

(b) *Increased resources approach*: It is assumed that merely increasing budgets will solve the problem;

(c) *System/organizational approach*: It is stated that a comprehensive system has to be established for the safe operation, maintenance and repair of equipment;

(d) *Regional approach*: Manufacturers' representatives must be assigned to regions rather than to specific countries.

The ISO family of standards and other quality programmes, such as total quality commitment, determine which elements of the production process are required to maintain quality regardless of the product manufactured in cases of both export and import. A key issue within those programmes is the inspection and testing of products.

It is evident that quality cannot be assured without strict control and accurate measurements. There is a need for well-planned quality management systems that rely on the background services of a country's instrumentation infrastructure. Without instrumentation infrastructure and suitable support instrumentation services, it is impossible to build up and operate the effective and economical quality systems that are needed by manufacturing companies.

In order to achieve the general objectives of the quality systems, a module system should be set up to make the best use of the national stock of instruments. Developing countries and countries with economies in transition vary considerably in their degree of development, their economic systems and their market environments. Despite this diversity, they share a number of common features. One of these is insufficient instrumentation infrastructure. According to the system approach, the elements of the instrumentation can be summarized as follows:

(a) *Instrument and measuring technique and investment consulting services*. In solving a measuring problem, it is important to choose the proper measuring method and the appropriate instruments. Institutes and companies are forced to change their profile often, so they must face new challenges from time to time. In new fields, they lack the instrumentation and expertise to use the instruments. They can choose from a wide variety of instruments. Instrument suppliers are aggressive in promoting their products, and it is difficult to obtain unbiased, objective advice when purchasing instruments. The above-mentioned problems create a steady demand for an effective consulting service. Such a service could be provided by staff who are experts specialized in different areas of measurement and instrumentation. Their personal expertise is extended by a comprehensive knowledge base, which consists of several independent databases, a catalogue and leaflet library etc.;

(b) *Training and education on how to run and maintain the instruments*. Education and training in all areas are identified as being of prime importance. Development of human resources is the cheapest way to invest with a relatively short-term return on investment. The lack of professional knowledge greatly hinders the efficient utilization of the instrument pool. The training needed for the operation and maintenance of test equipment should be carefully assessed before purchasing the equipment.

In the absence of such training, expensive equipment may not give the desired accuracy or may remain unused for long periods. In both cases, the result may be considerable material and moral damage. The training programme must cover all requirements for further education of the customers' experts, education and training of the engineers/technicians of the instrumentation support service centre (ISSC) and organized courses for outside experts (managers, service engineers);

(c) *Instrument maintenance and repair activity*. Precision measuring equipment is suitable only when it functions with the specified accuracy. Even instruments of the highest quality that are operated correctly will sometimes break down. For the repair and servicing of instruments, experts with suitable qualifications and skills, as well as spare parts, are needed. Developing countries may not have adequate facilities for repairing instruments, especially sophisticated testing instruments that have been imported. Arranging for visits of repair teams from abroad or sending equipment outside the country for repair is expensive and time-consuming. Servicing includes putting instruments into operation, their servicing during and after the warranty, and their repair, maintenance and overhaul. For that reason, local capability to provide repair and maintenance services must be established;

(d) *Renting and leasing of instruments*. Often, an instrument is needed only for a short period and would be redundant after the task is accomplished (e.g. while an instrument from the original set-up is under repair or calibration). In such cases, purchasing another instrument would be an unnecessary investment and delivery often takes a long time. Rental companies provide without delay instruments that are temporarily needed. The instruments are checked and calibrated according to specifications, and the customer only pays for the period during which the equipment is rented. Customers can even buy the rented instruments, either through leasing or direct payment;

(e) *Calibration*. Calibration plays an important role in the operation of quality systems. The measuring and testing activity is useful only if the results of measurements are reliable, that is, they are sufficiently accurate with a known degree of uncertainty. Calibration provides traceability, ensuring that the uncertainty level of every measurement made in the organization can be traced to known reference standards. A well-organized calibration scheme gives the manufacturer the certainty that the features of the products delivered are within the specifications and it gives the customer the assurance that he is buying exactly what he expects in terms of technical parameters and performance levels.

Calibration of measuring and testing equipment is essential to ensure the reliability of test data. For this, it is necessary to maintain a list of all equipment with associated details. The equipment register should also contain associated calibration details and the measurement standards against which the equipment has been calibrated. The calibration methods, procedures and references should be traceable to national or international measurement standards, and appropriate certificates should be available;

(f) *Procurement of instruments, marketing and trading*. The first step in establishing suitable inspection and testing facilities is the purchase of the equipment. Not every company has a purchase department well versed in instrument procurement and business transactions. Even general trading firms are unaware of the instrument market and the reliability of different instrument suppliers. Companies that do have experience in instrument trade can solve the complex task of instrument procurement more effectively;

(g) *Measuring technique services*. Instruments and testers alone are usually not enough to solve special measuring tasks. Specialized theoretical and practical expertise is indispensable. At times, companies cope with special measuring tasks that their own staff cannot solve. In such cases, prompt technical help is needed from companies that can send experts with the necessary knowledge and practical experience to solve a given task. Sometimes, in addition to the experts, special instrumentation is needed, so the service provider offers a turnkey solution to the problem;

(h) *Development and design of special-purpose instruments*. Very often, special measuring demands cannot be met by means of the general-purpose instruments currently available on the market. In such cases, special-purpose instruments or sensors with technical and construction specifications suited to the given task are required.

This order of support services is not in any order of priority. On any site, the list of services and the order of priority must be identified according to local requirements. The elements may be set up in the most practical sequence as defined according to the local requirements. The support services enable resources to be used more efficiently; each activity serves and helps to solve instrumentation management

problems. However, it must be emphasized that their complex use within the ISSC may even result in qualitative advantages, extended by a comprehensive knowledge base, which consists of several independent databases, a catalogue and leaflet library, a repair and maintenance service etc. This service can be built up step by step in a modular structure; if more modules are implemented, more effective support can be obtained from each module.

In developing countries, limited attention is paid to instrumentation at the policy and strategy levels. A commonly recurring problem in those countries is the absence of sufficient repair and maintenance services, which results in many instruments being out of order. Further, all the support services (consultancy, measuring, engineering etc.) needed for the safe and reliable operation of the quality systems are lacking. The status of instrumentation in developing countries in general results in wasted national resources and low efficiency and productivity of the instrumentation services. Optimal utilization of available precision measuring instruments can be achieved through the establishment of a local ISSC. The system approach to this lack of services enables all services needed for the operation of precision and control instruments to be managed together. The ISSC provides some or all of the services needed for the safe operation of precision measuring instruments. The main advantage of the ISSC concept is that the modules, which provide seemingly independent services, are implemented within the same organization and under the same management and each complements the other.

2. Chronology of the conception of the instrumentation support service centre strategy

Numerous workshops and training courses had been held on the repair and maintenance of measuring instruments, both in developing countries and in the training facilities of the instruments' manufacturers; however, the situation had not changed considerably in developing countries. The individually trained experts from developing countries had not formed a working unit or organization for providing instrumentation support services, which were needed for the safe operation of the quality systems. So the United Nations Industrial Development Organization (UNIDO) was looking for a technical solution to solve this problem.

Recognizing early the nature and magnitude of the problem, MTA-MMSZ of Budapest developed an institutional system for the efficient use of national instrumentation resources in Hungary.

The Hungarian system, according to UNIDO, appeared to be unique in its organization and services, responding to any complex problem and inquiry for instrumentation support services in a developing country. The capability to provide instrumentation support services can be built up step by step in a modular structure; if more modules are implemented, more effective support can be obtained from each module.

It was against this background that the Government of Hungary supported the proposal put forward by MTA-MMSZ in l986, and advocated by senior staff of UNIDO, to put the capabilities and services of MTA-MMSZ at the disposal of developing countries through UNIDO, in order to help them to improve their instrumentation infrastructure. That could be done by utilizing the experts of MTA-MMSZ in adapting the Hungarian method, known as the Stokum System (named after its originator), to meet all the needs of each country individually.

During the annual meeting of the Joint UNIDO/Hungary Committee held in Budapest in January l987, special importance was attached to instrumentation management problems. A study workshop was suggested as a first step, in the second half of 1987. As it was seen that cooperation between UNIDO and MTA-MMSZ would be beneficial for developing countries, the services and expertise available from MTA-MMSZ were outlined and discussed.

The *First UNIDO/MMSZ Workshop on Instrumentation Policies with Special Emphasis on Repair and Maintenance* was held in Budapest in October 1987. Attending the workshop were 20 participants from Algeria, Argentina, Chile, China, Egypt, Ghana, India, Jordan, Kenya, Morocco, Nepal, Turkey,

Venezuela, Viet Nam and Zambia, as well as UNIDO staff members. Also attending the workshop were observers for the International Atomic Energy Agency and the Swedish Agency for Research Cooperation with Developing Countries. During the discussion, new requirements for projects were announced and formulations for new projects were developed. The workshop recommended:

(a) Emphasizing to Governments the importance of the instrumentation policies, giving special attention to the repair and maintenance of measuring instruments;

(b) Developing a programme that adopts a systematic approach to the step-by-step improvement of instrumentation support services according to their requirements in developing countries;

(c) Assisting in creating a computer-based instrument registry database in developing countries and in promoting the exchange of such information between their local units through UNIDO;

(d) Promoting the adoption of incentives at the local units to keep the qualified/trained technical staff in their respective organizations.

In Viet Nam, it was recognized as early as 1989 that there was an urgent need for the development of instrumentation infrastructure. It was also recognized early on that the local ISSC also had to be incorporated in the technical infrastructure of the country, composed of the Bureau of Standards, Metrology Office and Quality Control Laboratories. Those institutions could act as an efficient basis for the development and realization of an effective national instrumentation supply, management and policies whereby they could also be of great help in the optimal utilization of the available financial, technical and staff resources.

As a first step the modules on repair and maintenance, after-sale service and consultancy were implemented in 1991. The Vietnamese ISSC was privatized within two years following the joint implementation of the project by UNIDO and the United Nations Development Programme (UNDP), and it is still working under market conditions.

In order to disseminate information on instrumentation support services in developing countries, in June 1992 MTA-MMSZ began preparing and circulating MMSZ Notebook, an information sheet for those concerned with technical instrumentation, whether they used instruments themselves or worked in donor organizations. Responses to questionnaires sent to the readers of the Notebook showed the high value they placed on the type of information provided in the information sheet. The mailing list of the MMSZ Notebook had more than 700 addressees. Most of the readers worked in research institutes or national research councils in developing countries. Others worked in national or multilateral donor agencies. The information sheet, published every two months, was sent to 100 countries. UNIDO sponsored the publication of the MMSZ Notebook in the period 1995-1997.

The Government of Pakistan recognized the need to develop instrumentation infrastructure, which is essential in managing the background instrumentation services necessary for the smooth operation of the instruments used in all economic areas in the country. The Ministry of Science and Technology requested the assistance of UNIDO in establishing a national electronic equipment and scientific instruments register and also in the preparation of a national instrumentation policy framework.

In the period 1997-1998, as the output of the project, the national instrumentation policy and the national instrumentation acquisition policy were drafted in the framework of a complex programme for the essential improvement of the level in measuring culture and its personal, technical and institutional background in Pakistan. Moreover, the final version of the National Electronic Equipment and Scientific Instruments Register (NEESIR) was installed on the personal computer system procured for that purpose in the National Institute of Electronics (NIE) in Islamabad. NIE staff were trained to use NEESIR. The necessary activities for self-sufficient operation in the future were also outlined jointly with the responsible experts of NIE.

The Physikalisch-Technische Bundesanstalt (PTB) of Germany and MTA-MMSZ convened a series of interregional workshops on this topic in 1995 and 1996. During those workshops, a summary was presented of experiences in the field in the previous 40 years and the changes in the economic system in Hungary. As a result of the workshops, preparatory work began in several countries to develop the instrumentation services using the Hungarian approach. In Cambodia, Morocco, Nepal and Uganda, official requests with project proposals regarding local ISSCs, as well as requests for assistance in the development of instrumentation services, were submitted to embassies of Germany. The appropriate local strategy for the maintenance of university equipment in Morocco was also built up, based on experience gained through participation in workshops and meetings organized mainly by UNIDO, PTB and MTA-MMSZ between 1987 and 1996 in Hungary and in other countries.

MTA-MMSZ, in cooperation with PTB, drew up a proposal to include instrumentation services in the development of the metrology, standardization, testing and quality management (MSTQ) infrastructure in developing countries. In the framework of the project “Support of MSTQ in African and Arabic countries”, a project was implemented by PTB on behalf of the Ministry of Technical Cooperation and Development of Germany. In the framework of this project, PTB asked MTA-MMSZ to prepare a plan consisting of three phases for the implementation of a feasible local ISSC in 1999 and suggested to UNIDO that it contribute to the implementation of the plan. In order to develop the safe operation of the quality schemes in developing countries, UNIDO considered positively the proposal of the PTB for cooperation in the field of improving instrumentation support services in member States of the Southern African Development Community (SADC). In that way, no new preparatory assistance would be needed in the case of the establishment of a local ISSC in Malawi. In Western Africa, the Standards Organisation of Nigeria, in Lagos, is implementing its local ISSC with UNIDO support. The detailed survey was accomplished in June 2001 and training was first carried out in December 2001, also with UNIDO support. By 2005 the Nigerian Instrument Registry had been put into operation and the Standards Organisation of Nigeria has established its repair workshop and acquired the minimum tools, measuring instruments and consumables from its own resources.

Self-sufficiency, after the execution of the project, is an essential criterion for fund mobilization. The systems approach proved sustainable in Hungary during its transition from a centrally planned economy to a market economy. It may provide the same possibility for developing countries. MTA-MMSZ was founded as an ISSC in 1957 to provide background services for academic institutes in measurement and instrumentation.

The company succeeded in becoming a profit-oriented, self-financing institution in 1974. By that time it was already providing country-wide services. At the time of the establishment of the institute, Hungary had a centrally planned economy and economic conditions were much like those of some developing countries. There was no free market and convertible resources were limited; however, technical links with developed countries had always existed. After the change in the economic system, the markets of the former socialist countries practically collapsed. As a result, many hundreds of large- and medium-sized enterprises became bankrupt.

Nevertheless, the institute survived and was able to flexibly adapt itself to the fundamental change in the economy. Its customers changed from large companies to small- and medium-sized enterprises. Though the number of professional staff was reduced by half, all its departments continued to operate with a minimal working configuration, all essential services being carried out by the most qualified engineers and technicians. Activities that did not yield profits were reduced or abolished. However, new activities were started (e.g. instrument purchase, leasing and trading) to meet the new requirements, and costs were reduced as much as possible.

Since 1992, as a result of the economic changes, the institute has been working as a profit-oriented, private company. Self-sufficiency was reached two years after the relevant decision. Institutes in developing countries might also establish their local, profit-oriented unit. Under one management, those services could be developed in such a way as to enable them to support one another and, at the same time,

all incentives necessary for keeping trained staff for longer periods and motivating them for maximum output could be used efficiently.

3. The impact of metrology and an instrumentation support service centre on social and economic development

The federal role in metrology is becoming even more important as domestic industries depend more and more on global trade to remain healthy. Entire industrial sectors require substantial expenditures on metrological infrastructure in order to compete effectively.

While developed countries allocate 3-6 per cent of their gross national product (GNP) to measuring and other related activities, most developing countries allocate negligible amounts, if any, of their limited GNP to such activities.

Low investment in metrological infrastructure leads to a lack of reliable measurement. Therefore, most developing countries are not able to obtain traceability or to participate in cross-country comparisons. Furthermore, lack of locally available calibration services affect both the quality of production and the cost when those services are acquired abroad or though international companies charging international fees.

Strongly linked to this is the capacity of a country to acquire modern technology and attract foreign direct investment (FDI). Low quality and unreliable suppliers deter multinational firms from investing in many developing countries. Improving the quality and productivity of local enterprises would induce higher levels of FDI, with the consequent positive effects on the economies of third world countries.

Poor quality standardization and metrology (QSM) infrastructure and skills result not only in the technology and FDI being impossible, but also in inadequate protection of consumers and of the environment (which is at least as important). For example, it is proven that the number of hospitalizations due to food contamination is still high, particularly in least developed countries (LDCs), where often food products do not conform to existing specifications or testing facilities are not available.

In today's global context, improving quality and competitiveness is the key to survival. Ignoring this fact, that is, not taking the necessary steps to overcome the bottlenecks that prevent industrial competitiveness from increasing, leads to company closures, increased unemployment and higher poverty levels. Conversely, improved enterprise competitiveness through upgraded QSM systems results in better enterprise performance and contributes to economic development, the reduction of poverty and the creation of employment.

4. Regional aspects of the development of instrumentation support services

The establishment of a local capability to provide all necessary services for the quality control laboratories is an urgent need. The optimal utilization of available precision measuring instruments can be achieved through the establishment of local instrumentation support services. Every country needs its local units for providing instrumentation support services.

Local ISSCs that are operating in a sustainable manner should serve as the basis for the implementation of the needed local units in neighbouring countries in the region. On the basis of the experience of the sustainable ISSCs the relevant networking activity can start in Eastern, Southern and Western Africa.

The instrumentation support service unit (ISSU) of the Malawi Bureau of Standards (MBS) has been in operation since 2002. MBS could increase the portion of its income from the repair activity provided for external customers. In this way the first steps towards self-sustainability have been taken. The ISSU of MBS could serve as the basis for a network in Southern Africa.

PTB started to implement this plan in developing the Instrumentation Department of the Kenya Bureau of Standards (KEBS) in 2000 by convening special training courses for the staff of the KEBS Instrumentation Department. On the basis of the priority order, the minimum tools, spare parts and measuring instruments were also delivered in 2001, so KEBS could serve as the basis for a network in Eastern Africa.

The Standards Organisation of Nigeria started to set up a local ISSC at the initiative and with the support of the UNIDO Regional Industrial Development Centre in 2001, provided services and nurtured the culture of repair and maintenance in Nigeria. The ISSC of the Standards Organization of Nigeria started providing the instrumentation support services for the Organization itself and for customers in Nigeria in 2005.

It is desirable for the units in the various regions to cooperate in the development of these services through networking to develop a means of exchanging information on: (a) experiences, problems and needs relating to the provision of instrumentation services; (b) second-hand precision measuring instruments reviewed by the members of the network, which can be used for repair purposes; (c) faulty highly sophisticated precision measuring instruments reviewed by the members of the network, which can be used for spare parts; and (d) the capabilities for the repair and maintenance of measuring instruments of the members of the network.

The other local units in Western Africa can use the ISSC of the Standards Organization of Nigeria as a basis for networking during the establishment and development of their services in their countries. With the involvement of resource persons (international consultants), training courses can be organized on:

- Design of local ISSCs
- Management, operation of ISSCs
- Sustainability of ISSCs
- Establishment, adaptation, operation and use of the country-wide instrument registry
- Engineering consultancy services provided for the customers
- Repair and maintenance of highly sophisticated precision measuring instruments
- Building up the necessary technical background under business conditions

During the XVI IMEKO World Congress held in Cavtat, Croatia in June 2003, networking activities were decided by KBS, MBS, the Standards Organisation of Nigeria and the Network of Users of Scientific Equipment in Eastern and Southern Africa (NUSESA) with the aim of developing these services in Africa.

NUSESA has become a competent and renowned network of users of scientific equipment for Eastern Africa and Southern Africa that can contribute effectively and efficiently to the development of those regions. NUSESA builds scientific capacity in the delivery of quality services and products in various aspects of scientific equipment and thus contributes to development and integration in Eastern and Southern Africa by serving the scientific community through the establishment of a network for impeccable equipment, application, administration and maintenance.

Considering the present situation in Eastern and Southern Africa, there is an urgent necessity to develop instrumentation support services. Without significant development in the near future, the existing quality schemes and quality systems cannot operate effectively.

5. Development of instrumentation support services (plan)

A best practice road map was created on the basis of almost 20 years of experience in the development of a local and regional capacity to offer maintenance and support services for industry and institutions. Throughout the workshops and in the implementation of the various projects in Kenya, Malawi, Nigeria, Pakistan and Viet Nam, it was shown that the most efficient and promising way to establish an ISSC is to divide the project into three phases and use a modular structure and step-by-step implementation to achieve a successful and self-sustainable metrological unit (see table 1). The main advantages of this plan are as follows:

(a) The instrumentation background services necessary for the smooth operation of the projects implemented under the donors' aid programme could be facilitated through local services on a long-term basis;

(b) The assistance of the donor in the instrumentation services field would also support, among others, the operation of the quality control systems in the recipient developing countries;

(c) The human resource base of the recipient developing country is enhanced;

(d) Better utilization of instrumentation resources can be achieved;

(e) A culture of engineers and technicians for instrumentation and measuring can be created; and

(f) Because of its modular structure, step-by-step implementation is possible.

Table 1
Establishment of an instrumentation support service centre

Output	Activity	Party responsible
First phase:		
1. Establishment of management with working unit	1. Appointment of manager of the working unit: the responsibilities of the manager must be detailed	1. Local institute (outside consultancy is needed)
	2. Forming the working group	2. Local institute
	3. Appointment of analytical expert from another department to cooperate in trouble-shooting	3. Local institute
	4. Organization of cooperation of an analytical expert with the working unit	4. Local institute (outside consultancy is needed)
2. Establishment of a database of measuring instruments	1. Collection of data	1. Local institute
	2. Implementation of software (a) Appointment of a data officer of the working unit (b) Finalization of input and output data (c) Adaptation of software (d) Acquisition of data according to the registration form (e) Fellowship training of the data officer of the working unit (f) Putting into operation adapted software and feed with collected data	2. Donor
	3. Regular updating of data	3. Local institute

Output	Activity	Party responsible
3. Establishment of the running of the laboratory for the working unit	1. Provision of laboratory 2. Application of existing measuring instruments 3. Involvement of analytical experts	1. Local institute 2. Local institute 3. Local institute
4. Training of staff	1. Evaluation of priorities in the lists of measuring instruments 2. Elaboration of a training programme 3. Identification of the training site 4. Implementation of consecutive fellowship training sessions (first training session lasts for about four weeks at least)	1. Local institute 2. Donor 3. Donor 4. Donor
5. Provision of services for customers	1. Distribution of information on instrumentation support services to clients 2. Establishment of a consultancy unit 3. Concluding service contracts with clients; sending consultant's expert to the local institute for one month. 4. Evaluation of phase 1	1. Local institute 2. Local institute with donor support in consultancy 3. Local institute with donor support in consultancy 4. Donor
Second phase: 1. Development of the running conditions of laboratory for the working unit	1. Delivery of measuring and controlling instruments necessary for the maintenance and controlling of the repair work	1. Donor and local institute
2. Provision of services for customers	1. Establishment of an e-mail advisory unit for identifying the technical problems and the spare parts needed for faulty measuring equipment 2. Training in the acquisition of spare parts 3. Evaluation of the work of the local working unit	1. Donor 2. Donor 3. Donor
3. Service contracts with the instrument suppliers	1. Consultancy to the local Working unit based on the evaluation 2. Conclusion of service contracts 3. Support to the local working unit from the suppliers	1. Donor 2. Local institute with donor consultancy 3. Instrument suppliers (donor consultancy is advised)
Third phase: 1. Establishment of further support service units of the ISSC	1. Analysis of the requirement of the local market 2. Establishment of the necessary units based on the analysis	1. Donor and local institute 2. Donor and local institute

The main aspects of this plan are described below.

(a) Management aspects

The importance of the management aspects (definite leadership, organization, motivation, functions, responsibilities, layout, stores, workplace, furniture etc.) of the establishment of the local ISSC cannot be overemphasized. The reorganization of existing units (personnel, layout of the workplace, administration) is suggested. The ISSC Unit has to be a profit centre, which prepares its own profit and loss statement; its costs and income have to be separated from those of the other units of the institute. It is necessary to increase the individual responsibility of the repair persons. During the repair procedure, all steps for carrying out the repair work must be recorded, including the name and the action of the person who carried out the work. Showing a high level of responsibility will protect the instruments from suffering damage during the repair period and ensure that the instrument remains in the same technical condition as it was when it was sent for repair. The different functions in the ISSC (repair, procurement/import, administration) must be separated. A person responsible for each function must be appointed and must be able to carry out the work in an efficient manner, step by step.

(b) Technical background

To be able to continuously identify the order of priority of the instrumentation support services and to focus the efforts to solve problems in an efficient way, the establishment of a computer-based instrument registry is needed. The registry is an essential tool for management in analysing the problems of the precision measuring instruments in the country, identifying the order of priority of the problems and providing services. In the later phase, the registry can also be used to work out the purchase policy for customers or large organizations (ministries, universities etc.). Data on the measuring instruments of customers (loaded into the registry computer) must be regularly updated.

The technical staff (consultants, repair engineers, operator of the registry) must be selected carefully, step by step. Use of the incentive system to retain efficient personnel is essential.

It is necessary to provide work areas (consultancy room, workshop, stores for the instruments, spare parts, room for dirty jobs) and furniture (furniture for storing incoming and outgoing instruments separately, storing personal instruments and catalogues in closed cabinets and storing consumables (some of which are poisonous and inflammable) and a separate table with drawers for each person). The tools and measuring instruments and equipment can be acquired gradually, partly in the domestic market using one's own resources and partly from abroad using donor support.

All technical materials (technical descriptions, data sheets, catalogues, operation manuals etc.) must be collated. The sources of technical documentation of old measuring instruments, continuous support in special technical expertise and special spare parts must be established for the ISSC. Information channels must be built up.

It is necessary to have direct access to communication, such as Internet access, to obtain information from the Web, e-mail access for information exchange, and an address for receiving catalogues, data sheets and manufacturers' brochures.

(c) Consecutive evaluation of sustainability

Self-sufficiency, after the execution of the project, is an essential criterion for fund mobilization. For that reason, consecutive, comprehensive evaluation of each step of implementation is needed. If the result of the evaluation shows an increase in the sustainability of the instrumentation support services provided by the local unit, the next phase can begin. This approach enables the efficient use of funds.

(d) Decreasing support from outside

The sustainability of such services should include the long-term operation of the local ISSC while reducing support from outside. However, without outside support (financial and technical), the establishment of the local capabilities for providing the necessary services is not possible.

II. UNIDO at work: the case of the instrumentation support service centre in Malawi

A. The situation at the beginning of the UNIDO project

1. Feasibility of the establishment of a local capability in the Southern African Development Community

The findings of the survey in the Southern African Development Community which was carried out by MTA-MMSZ (at the request of PTB) in 1999, are summarized below.

The measuring instruments, which are needed for the operation of quality schemes and quality systems, are imported or donated in the framework of different aid programmes without considering the necessary support services. No instrumentation policy has been in force during the acquisition process, neither at the institute level nor at the country level. In this way, a great variety of suppliers can be identified without knowing any of the priorities of the country or institutes. A large number of instruments are not functioning because of the lack of proper training and repair and maintenance (R and M) services. In many cases, spare parts and consumables were worn out during the measuring procedure, and the training necessary for the use of the instruments was also lacking. The missing parts and consumables could not be purchased in the local market. The expertise for R and M consultancy for the use of equipment is lacking. Because of the lack of funds, only limited technical service can be provided for the users of instruments, and those limited services can only be provided through marketing representations with considerable delay. Without outside support, such services cannot be established.

The only solution is for local service units to be organized to provide the necessary complex support services in their countries. Considering the privatization in those countries and the need for those services, both in the Government and in the private sector, those units under suitable management could work on a sustainable basis after receiving initial support. In a later phase those local units could begin cooperation with selected manufacturers. Those local units already operating and those planned need outside support in their management of these complex services, identifying and analysing the priority needs for support services, establishing and developing their technical expertise and providing initial support in identifying and purchasing the spare parts and consumables.

The clients, both in the Government and in the private sector, are ready to pay for the services of local units if they provide flexible, suitable instrumentation support services; those services can be controlled and the problems discussed and eliminated after payment (in this way, the guarantee for the services has also to be provided). The only way to ensure confidence in the efficiency of work is to carry out a step-by-step evaluation of the establishment of the services. That approach requires the gradual implementation of the three-phase plan (see the subsection above entitled “Development of instrumentation support services (plan)”).

B. Implementation strategy

1. Step-by-step approach using consecutive evaluation

As for the modular structure of the ISSC, its establishment can be carried out gradually so that effective use of resources can be achieved. After a survey of the most important needs of different services (consultancy, repair and maintenance etc.), steps should be taken towards the establishment of the first units of an ISSC. In Malawi, repair and maintenance and the consultancy unit with the instrument registry were selected as the most important services. In the case of the repair and maintenance of old measuring instruments, it is essential to have information from the customers on the conditions of all measuring

instruments in the country, which is needed to establish an instrument registry. The work started with one full-time electronic engineer and five persons (two of them heads of units) applied for part-time work.

It is necessary to analyse the needs for instrumentation services and identify the order of priority of requirements using the instrument registry. The continuous updating of the order of priority is essential to be able to focus the efforts on providing those instrumentation support services which are necessary for the safe operation of the quality systems.

In Malawi, MBS was responsible for the analysis of the local needs using the assistance of the subcontractor. The Hungarian subcontractor was responsible for the adaptation of the software, which was necessary for the establishment of a country-wide database of measuring instruments and the provision of special training for local staff.

After the measuring instruments were collected by MBS, the priorities of the measurements were determined and the groups of measuring instruments (e.g. optical equipment/spectrophotometers, spectrometers, colorimeters, refractometers, chromatographs, heating elements, sensors etc.), together with the technical specifications of selected measuring instruments having high priority and the data of manufacturers, were identified. That database served as the basis for the identification of the needs of the country for instrumentation support services and all further work and the consultancy service to be provided for customers.

The first special training course had to be adjusted to meet the country's priority needs in measurements. The courses in the MBS laboratories were organized for the repair technicians and selected analytical experts (operators) who were the users of the selected instruments; and the course had to be carried out in the laboratories where the selected measuring instruments were put into operation.

The first part of the training was to teach the operators (and give them an opportunity to practise) preventive maintenance of the selected measuring instruments, in addition to providing them with the necessary theoretical information. The second part of the training provided instructions for the repair technicians and the operators on parts or units of different types or groups of instruments selected as being the most likely to be damaged, in addition to explaining to them their duties. The third part of the training provided assistance to the repair staff in the maintenance and repair of selected measuring instruments, focusing on the activities of maintenance, calibrations, trouble-shooting and repairs. The fourth part provided for training the repair technicians on the necessary administration of maintenance and repair activity, documentation (records on repair activity etc.), knowledge of proper specification of faulty and spare parts, accessories, consumables, possible sources of parts and accessories, and communication possibilities where advice could be found in the course of the repair work. In this way, the basis of proper administration of the repair work (including preparation of the drafts of internal and external forms for records) was developed. At the end of the first course, one week of training was organized in South Africa, where the technical background of the repair and maintenance activity could be studied and connections for the necessary technical support could be established.

On the basis of the training, the local staff were able to accomplish the tasks that were prescribed for them by the subcontractor's expert.

The practice of the ISSU of MBS and the results of the steps towards sustainability were evaluated and the curriculum of the second special training course was adjusted according to the findings of the evaluation. Further advice was given to MBS management on developing the operation of the cost centre and the collating of the information on the precision measuring instruments of the customers.

After the implementation of the first phase, all activities (operation of the instrument registry, repair and maintenance activities, operation of the cost centre) must be evaluated. If the analysis shows that the ISSU of MBS has achieved positive results in increasing sustainability, the convening of further consecutive special training courses (lasting 3-4 weeks at least at the site, at six-month intervals) is advised as well as the second phase (see the section entitled "Development of instrumentation support

services (plan)") for providing the high-value precision measuring instruments, which are needed for the repair activity. The implementation of each phase must be evaluated, taking into account to what extent the sustainability of the local unit has been increased. A successful evaluation result or proper evidence of the successful operation of an existing local repair unit is necessary for the next phase to begin. The operation of the local repair unit can be evaluated as successful if its income can cover a considerable part of its costs.

2. Recommendations of the International Organization for Standardization

As a result of the standardization programmes and the implementation of ISO 9000 requirements, quality management systems (QMS) have been established in Malawi. International standard ISO 10012:2003 (Measurement management systems—requirements for measurement processes and measuring equipment) specifies generic requirements and provides guidance for the management of measurement processes. It also contains guidelines on metrological confirmation of measuring equipment used to support and demonstrate compliance with metrological requirements. In addition, this international standard specifies the quality management requirements of a measurement management system. Such a management system could be used by organizations performing measurements as part of their overall management systems and to ensure that metrological requirements are met. These general requirements are formed to meet the demands between an organization and its clients and to fulfil the requirements of other ISO standards such as ISO 9001 and ISO 14001. International standard ISO 9001 promotes the process approach for quality management systems. Measurement processes are a specific subset of processes that form an essential part of any quality management system and, therefore, follow the same process approach (integrating the process-based approach) to ensure that it can be implemented seamlessly as part of an organization's overall management system.

When measuring equipment is found to be inaccurate or otherwise faulty, it is usual to adjust, overhaul or repair it to function correctly. The adjustment or repair, and the measuring technique confirmation processes (see figure I below), according to the related ISO prescription, must be carried out by staff having appropriate qualifications, training, experience, aptitude and supervision; all adjustment and repair activity must be recorded. An important part of a confirmation process is the calibration according to the prescriptions of international standard ISO 17025.

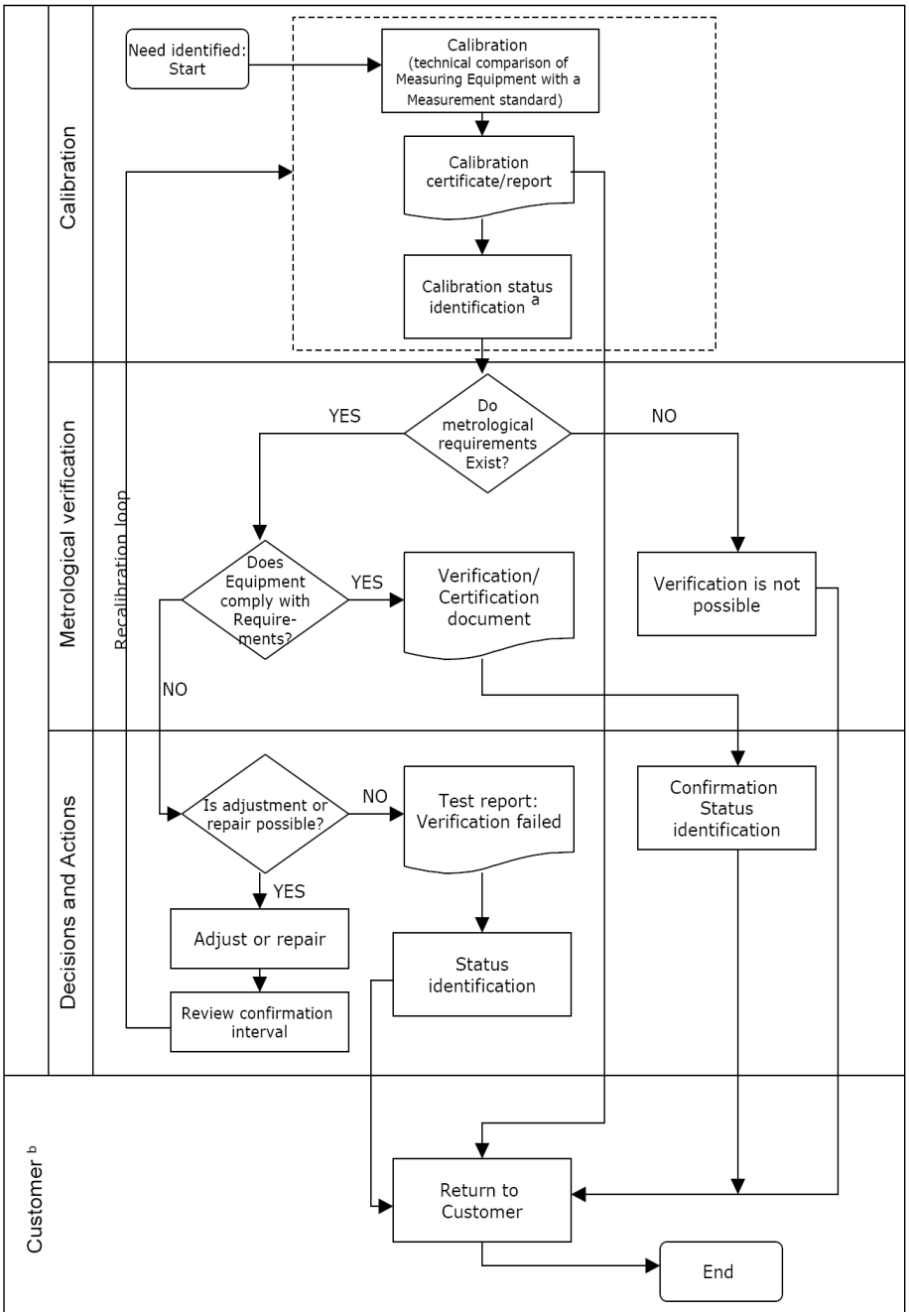
Contractual obligations are needed among the users of measuring equipment and the local unit of MBS, which is providing instrumentation support services. In this way, the step-by-step application of the programme for the establishment of these services, with emphasis on the self-sustainability of the local unit of MBS, in the long run benefits the users of measuring instruments in food-quality control and other laboratories, as well as society as a whole.

The important requirements for measuring equipment in international standard ISO 10012:2003 are as follows:

- Measuring equipment can be confirmed for use in particular measurement processes. All measuring equipment must satisfy the specified metrological requirements. Metrological requirements for the measuring equipment are derived from specified requirements of the product or the equipment to be confirmed. The metrological characteristics of measuring equipment shall be suitable for its intended use.
- Nonconforming measuring equipment: Any item of measuring equipment that has suffered damages, that has been overloaded or mishandled, that shows any malfunction, whose proper functioning is subject to doubt, that has exceeded its designated confirmation interval or the integrity of whose seal has been violated, that produces incorrect measuring results or that has a damaged or broken seal or safeguard shall be removed from service by segregation or be identified by prominent labelling or marking. Such equipment shall not be returned to service until the reasons for its nonconformity have been eliminated and it is again confirmed.

Preventive action should eliminate the causes of potential nonconformities, with a view to preventing their occurrence.

Figure I
Metrological confirmation process



[a] Calibration identification labelling may be replaced by metrological confirmation identification.

[b] Organization or person receiving a product (e.g. consumer, client, end-user, retailer, beneficiary or producer); customer may be internal or external to the organization (ISO 9000-2000).

- Intervals of confirmation: Measuring equipment (including measurement standards) shall be checked at appropriate intervals (usually periodic), established on the basis of their stability, purpose and usage. The intervals shall be such that confirmation is again carried out prior to any probable change in accuracy that is of significance in the use of the equipment. Depending on the results of calibrations at preceding confirmations, intervals of confirmation shall be shortened, if necessary, to ensure continued accuracy.

- Environmental conditions: Measurement standards and measuring equipment shall be calibrated, adjusted and used in an environment controlled to the extent necessary to ensure valid measurement results. Due consideration shall be given to temperature, rate of change of temperature, humidity, lighting, vibration, dust control, cleanliness, electromagnetic interference and other factors affecting the results of measurements. Where pertinent, these factors shall be continuously monitored and recorded and, when necessary, correcting compensations shall be applied to measurement results.

The practice of individual invoicing does not provide enough leeway for planning future repair activity (larger development in acquisition of an expensive measuring instrument, which is necessary for the repair of sophisticated measuring instruments, further recruitment of technical staff etc.) and preparing estimates of MBS income from repair and maintenance for longer periods. At the same time, this practice does not provide that service for customers, which is needed and called for in the relevant ISO recommendations.

In order to assist MBS in concluding service contracts with its customers, two types of service contract were developed on the basis of discussions with customers, in cooperation with MBS management. The contract for repair and maintenance is a draft for the lump-sum contract between MBS and its customers that can be concluded for a longer period for the specified measuring instruments of the customers. Such contracts meet the requirements arising from the ISO recommendations. Because of the special verification questions of the overhaul jobs, another draft was worked out. MBS can use that draft if such work is ordered from the customers. The elaboration of the new service contracts with the customers is under way. The ISSU of MBS, in the framework of the service contracts, can provide those services to the customers which are recommended by international standard ISO 10012.

C. The instrumentation support service centre in Malawi

1. Aspects concerning the selection of the organization in Malawi

As a result of the selection procedure, MBS was chosen as a partner institute. This institute had endeavoured to ensure the continued smooth functioning of the manufacturing and service sectors of the industry in the country by developing standards and offering testing and inspection facilities and by carrying out the independent qualifying activity needed for industrial and agricultural production and the importation of goods into the country. It had also made efforts to improve choice, safety, quality and compatibility in purchased and produced goods and services. The institute had worked continuously to facilitate trade by specifying minimum requirements for products and services for local and foreign markets. It had provided calibrating services linked to national primary standards for the quality control laboratories of the production firms and had educated industrialists on how to develop standards and how to carry out quality control measurements. Thus, the institute had good contact in industry, agriculture, higher education, public health etc., in both the private sector and the public sector of Malawi.

(a) Management aspects

Before taking a final decision on the selection, the activity of the management was studied. Without definite management, the step-by-step development of the local unit could not be carried out. The study of the operation of the existing management, its responsibilities and functions, provided information about

the possibilities for creating a cost centre, future accomplishment of definite aims, plans, necessary appointments, new recruitments, the use of possible income for the development of the local unit and the application of the necessary incentive scheme. Its readiness for accepting new ideas and for cooperation was also investigated.

(b) Aspects concerning the technical background

It was determined whether the necessary work areas (consultancy room, workshop, stores for the instruments, spare parts, room for dirty jobs) could be made available without having to engage in any building activity and whether existing infrastructure (power supply, telephone lines etc.) could be used.

Interviews were conducted with the technical staff (consultants, repair engineers, operator of the registry) so that suggestions could be made for further action regarding education, training and possible new recruitment. The possibilities for cooperation between the qualified operators of sophisticated precision measuring instruments and the repair engineer were also studied.

2. Malawi: economic conditions and performance

(a) General information

Malawi has a total land area of 118,480 km^2 (slightly smaller than the state of Pennsylvania in the United States) and a population of 12 million (according to 2000 statistics). Lilongwe is its capital. Blantyre, in the south, is the centre of economic and business activity.

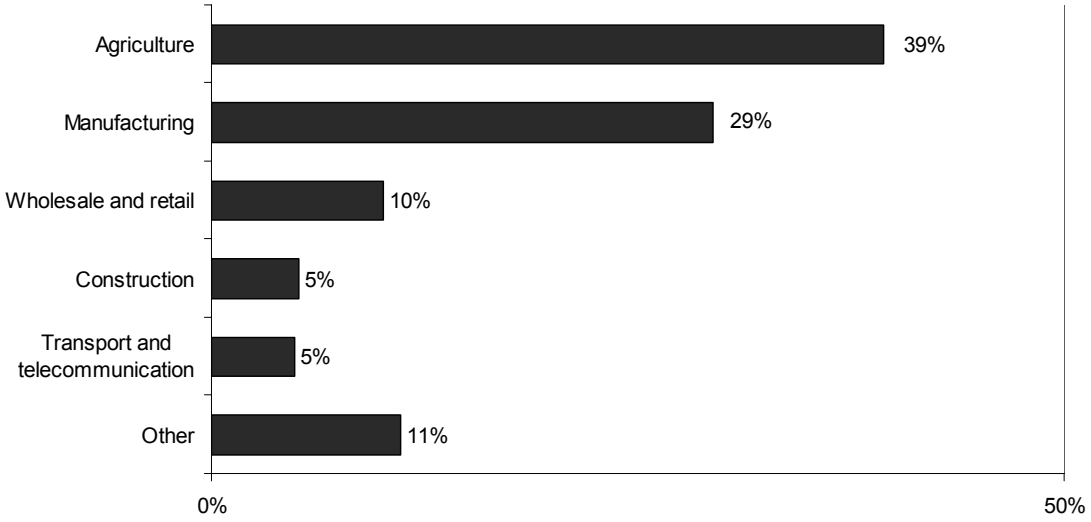
Malawi is one of the small landlocked countries in Southern Africa. So far, there has been only one successful development model for countries with such characteristics: that of western European countries such as Austria and Switzerland. The success of such countries rests on their ability to integrate themselves into the region. As a result of the region's success, being landlocked does not usually cut these countries off from their market; instead, they are usually at the centre of their market, trading with the countries in the coastal areas of the region. Such an option has not been available to Malawi because the coastal economies have not been successful enough to constitute import markets.

Although Malawi has avoided both internal conflict and major policy blunders for 40 years, it has little to show for its efforts. It is classified as an LDC by world standards and has a relatively small economy.

According to UNDP indicators, the human development index rating of Malawi in 2002 was 0.388, putting it in 165th place in a list of 177 countries.

Malawi's economic reliance on the export of agricultural commodities renders it particularly vulnerable to external shocks such as declining terms of trade and drought. High transport costs, which can comprise over 30 per cent of the total import bill, constitute a serious impediment to economic development and trade. Malawi must import all its fuel products. Economic development in Malawi is further hindered by the paucity of skilled labour (see figure II); difficulty in obtaining expatriate employment permits; bureaucratic red tape; corruption; and inadequate and deteriorating roads, electricity, water and telecommunications infrastructure. However, recent government initiatives targeting improvements in road infrastructure, together with the participation of the private sector in the railroad and telecommunications systems, have begun to make the investment climate more attractive (see table 2).

Figure II
Malawi: share of average employment, 1999-2001



Source: National Statistical Office of Malawi.

Table 2
Average sectoral growth and shares of gross domestic product, 1994-2004
(Percentage)

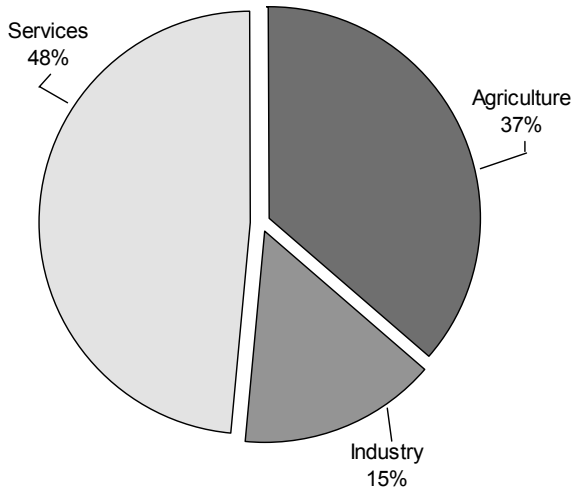
Item	*Average share*	*Average growth*
Gross domestic product at factor cost	100.00	4.10
Agriculture	35.95	14.91
Small-scale	28.12	10.98
Large-scale	7.83	3.93
Mining and quarrying	1.19	14.55
Manufacturing	13.02	-0.58
Electricity and water	1.41	3.40
Construction	2.22	6.13
Distribution	22.46	1.66
Transport and communication	4.56	3.55
Financial and professional services	7.98	6.74
Ownership of dwellings	1.47	2.43
Private social and community services	2.12	3.71
Producers of government services	10.61	-0.70
Unallocable finance charges	-2.99	5.36

Data source: National Statistical Office of Malawi.

(b) Agricultural production and trade

The economy of Malawi is predominately agricultural, with about 90 per cent of the population living in rural areas. Agriculture accounted for nearly 50 per cent of the gross domestic product (GDP) (see figure III) and 81 per cent of export revenues in 2002.[1] Its two most important export crops are tobacco and sugar. Malawi has high agriculture potential, with 402,83.2 km^2 of arable land (34 per cent of the country), 86 per cent of which is cultivated.

Figure III
Malawi: structure of the economy, 2002
(Percentage of GDP)



Source: World Bank.

For its agricultural production (both food and export crops), Malawi relies on its peasant families and small- and medium-sized commercial farms (see table 3). Factors hampering steady production include lack of appropriate technology for small-scale producers, who often lack farming materials and store their crops using local technology. That situation contributes to low yields, post-harvest losses and low-quality crops. Poor infrastructure (inadequate roads, grain stores and warehouses) affects agricultural output and is reflected in high costs and frequent bottlenecks in the distribution of produce. These developments have major implications for the issues of standards and quality. In particular, quality is not a determining factor in the marketing of products on the domestic market, partly because of the level of poverty and the need to satisfy basic requirements and partly because of lack of awareness. Although traditional export products are well known and their market is secure, some appear to command lower prices abroad than would otherwise be the case, apparently because of poor quality. This has had a negative impact on the income-generation potential for the farmers of those crops. GDP was US$ 1.9 billion in 2002,[2] the principal exports being tobacco (59 per cent), sugar, molasses and honey (13 per cent), and tea and mate (9 per cent) (see figure IV). Main industries are based on the processing of agricultural produce into commodities such as tea, coffee, tobacco and sugar. Other products include cement and consumer goods. Deposits of minerals such as bauxite, asbestos, graphite and uranium are known to exist but have not yet been mined. Coal is produced on a small scale, and its production may increase near the border of the United Republic of Tanzania.

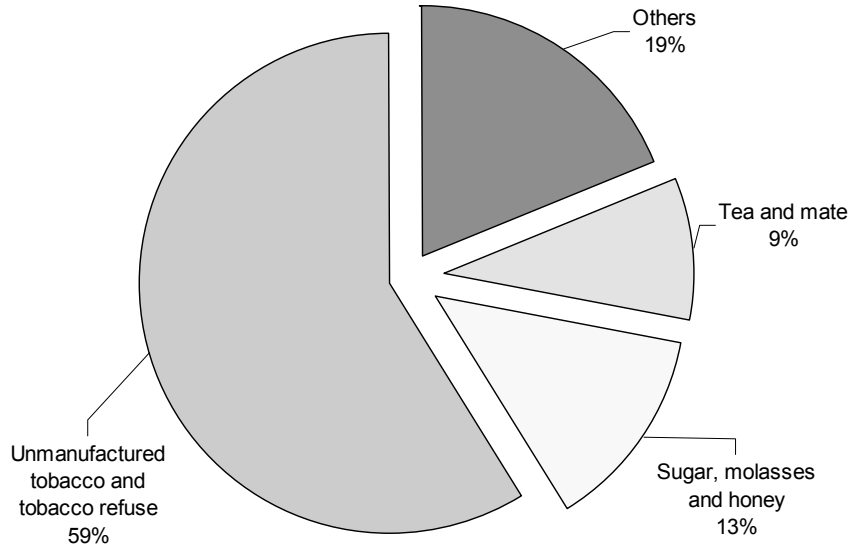
[1] World Bank, *World Development Indicators 2004* (Washington, D.C., March 2004).
[2] Ibid.

Table 3
Economic indicators of micro and small enterprises, by sector, 2000

	All sectors	*Crops*	*Livestock*	*Forestry*	*Fishing*	*Mining*	*Manufacturing*	*Construction*	*Commerce, trade, hotels*	*Transport*	*Services*
Distribution of enterprises (thousands)											
Enterprises	747.4	160.8	7.3	9.6	11.0	0.9	206.4	6.5	306.7	4.7	33.6
By size:											
0-4 employees	674.1	113.4	5.2	9.6	6.8	0.8	200.6	5.1	296.9	4.4	31.4
5-20 employees	72.3	46.8	2.1	-	4.1	0.1	5.8	1.4	9.5	0.3	2.2
21-50 employees	1.0	0.6	-	-	0.1	-	-	-	0.3	-	-
By annual sales (Malawi kwacha):											
< 2,000	15.5	-	-	0.7	0.1	-	4.4	-	8.9	-	1.3
2,000-5,999	62.3	0.6	-	3.0	0.3	-	30.7	0.1	22.2	-	5.4
6,000-9,999	117.9	51.8	1.1	2.0	0.1	-	31.6	1.0	25.9	0.5	3.9
10,000-19,999	163.2	55.2	2.2	2.3	1.3	0.3	43.5	0.9	50.1	0.6	6.9
20,000-49,999	177.2	38.8	2.0	1.1	2.1	0.3	53.5	0.9	68.7	0.4	9.4
50,000-100,000	98.7	10.5	0.9	0.2	1.9	-	23.5	2.7	55.9	0.5	2.6
> 100,000	112.6	4.0	1.1	0.3	5.1	0.4	19.1	0.9	75.0	2.7	4.0
By annual profits (Malawi kwacha):											
< 2,000	75.1	4.8	-	1.2	0.3	-	22.3	-	34.3	-	12.2
2,000-5,999	185.8	39.8	1.1	4.4	0.5	-	63.3	1.2	70.3	0.9	4.2
6,000-9,999	143.4	45.4	2.2	1.6	0.7	-	39.5	0.6	47.5	0.1	5.8
10,000-19,999	141.7	41.1	0.9	1.5	1.9	0.3	38.0	0.9	51.9	0.4	4.6
20,000-49,999	119.8	22.4	1.3	0.5	2.5	0.2	26.4	2.8	60.2	0.6	3.0
50,000-100,000	47.1	5.5	1.1	0.1	1.5	0.1	9.8	0.7	25.5	0.9	1.8
> 100,000	34.6	1.8	0.7	0.3	3.6	0.3	7.1	0.2	16.9	1.7	2.0

Source: National Statistical Office of Malawi.

Figure IV
Malawi: distribution of exports, 1999-2003



Source: Commodity Trade Statistics Database (COMTRADE) of the Statistics Division of the United Nations Secretariat.

The principal markets for Malawian exports are Europe and North America. Bilateral trade agreements with South Africa and Zimbabwe allow duty-free entry of Malawian products into those countries.

The domestic agro-industry consists mainly of medium-scale processing of agricultural raw materials into primary commodities and includes a small-scale food-processing subsector. The remaining industrial transformation is undertaken within small family units for their own consumption or local sales. Thus agro-processing in Malawi has not been able to absorb the agricultural produce that is currently grown in the country. This leads to the export of basic raw materials with little value added and to the dependence of the country on imports of consumable agricultural goods.

Natural disasters (floods, cyclones and drought) strike the country almost every year and have destroyed crops, killed livestock and damaged factories in the affected areas. Natural disasters worsen the situation with regard to food insecurity, both chronic and temporary, that prevails in some parts of the country.

(c) Macroeconomic instability

Macroeconomic instability has been a major problem in recent years. The Government of Malawi has been attempting to control public spending through the introduction of a framework for medium-term expenditure, but budget deficit targets (for example, 1.9 per cent of GDP for fiscal year 2001/02) tend to be unrealistic. Between 60 and 70 per cent of government expenditure is funded from external sources in the form of grants and loans. There has been rapid growth in money supply and inflation, as the Reserve Bank of Malawi covered the government budget deficit with internal credit. Open-market operations, mainly the issuance of treasury bills, have been used in an attempt to minimize the inflationary effect of public sector borrowing and to support the national currency, the Malawi kwacha (US$ 1 = MK 114.84 in June 2005). This has resulted in high nominal and real interest rates. High levels of inflation have historically made the kwacha vulnerable to depreciation, but a rare appreciation occurred in 2001 that caused profit uncertainty among traders who had signed future contracts in United States dollars.

Tobacco export revenues are expected to increase, following a switch to the higher-value flue-cured tobacco and an improvement in the quality of the burley tobacco crop. However, declining international prices for coffee and tea are reducing export receipts from those crops.

3. Role of standardization and quality in Malawi

The Government of Malawi, realizing the importance of the role of standardization, quality assurance, accreditation and metrology (SQAM) in the economy, established in 1972 the Malawi Bureau of Standards (MBS) as the body responsible for the elaboration of national standards and the coordination of SQAM. MBS, established as a statutory corporation with a board, was given the mandate of promoting the standardization and quality of commodities and of their manufacture, production, processing or treatment.

In order to fulfil this mandate, MBS established programmes aimed at addressing the various areas of SQAM, including:

- Development and publication of Malawian standards
- Establishment of quality assurance services
- Establishment of laboratory testing services
- Establishment of export quality certification
- Establishment of import quality certification
- Establishment of eco-labelling certification
- Establishment of an industrial consultancy on product improvement and quality management training
- Establishment of a service providing information on standards

Those programmes required a certain level of investment by the Government of Malawi, with the support of the private sector and the donor community, in infrastructure for SQAM. That investment in buildings, hardware and equipment, as well as human resources (in the form of development of national experts in SQAM), has over the years yielded positive returns and assisted the economy in coping with global competitiveness and the requirements of the Agreement on Technical Barriers to Trade[3] and the Agreement on Application of Sanitary and Phytosanitary Measures.

4. Profile of the Malawi Bureau of Standards

MBS is a correspondent member of ISO. MBS also represents Malawi in the Codex Alimentarius Commission of the World Health Organization and the Food and Agriculture Organization of the United Nations as the national contact point on food standards and safety. Malawi, as a member of the World Trade Organization (WTO), has appointed MBS as the National enquiry point for the Agreement on Technical Barriers to Trade and the Agreement on Application of Sanitary and Phytosanitary Measures. MBS therefore coordinates all matters related to standards and quality for the Malawian economy.

The institutional quality policy of MBS reads as follows:

> "We will spearhead the promotion of standardization and quality in Malawi effectively, efficiently and in a sustainable manner for the benefit of the nation and its economy, and continuously strive to improve our services to the satisfaction of the nation."

MBA has developed and published a national quality policy to guide all key players and stakeholders in the economy on matters of quality.

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[3] United Nations, *Treaty Series*, vol. 1868, No. 31874.

In line with its mandate and its role in the economy, MBS has put in place the following programmes:

- *Development of standards*: MBS develops and publishes national standards on products, commodities, processes and guidelines in accordance with the requirements of WTO and ISO standards. It does this through a structure comprised of: 39 national technical committees; three divisional committees; one Standards Policy Advisory Committee; and MBS, the body responsible for the approval of the standards according to the law. The published national standards of Malawi are aligned with international standards (ISO, the International Electrotechnical Commission, the International Organization of Legal Metrology and the Codex Alimentarius Commission). This is to ensure that the standards that are published in the trade sector are user-friendly and promote the competitive potential of Malawian exports on the global market.

- *Quality assurance services*: The implementation of the national standards is overseen through a special programme called quality assurance services. Under that programme, the following are carried out: product and process certification; export quality certification; import quality monitoring scheme; eco-labelling certification; and service for handling consumer complaints.

- *Technical services*: A programme for technical services provides facilities for testing products and commodities through laboratories of MBS covering, among other things, the following areas: chemical technology testing; microbiology analysis and examination; pesticide residue analysis; petrochemical analysis; engineering and textile testing; building material testing; and radio-chemical analysis. The work of the programme covers both external client samples and the work of the internal certification activities.

- *Metrology services*: MBS metrology services cover two main areas: trade and legal metrology and industrial metrology. However, it is only in the first area that services are being carried out, as facilities for industrial metrology are not in place yet.

- *Industrial Research and Consultancy Unit*: As part of its integrated approach to the promotion of quality and standardization in the private sector, MBS established an Industrial Research and Consultancy Unit to provide a special service. The objectives of the service are to assist industry in developing and designing products and processes that comply with both company and national standards; to assist industry in implementing systems to enable them to consistently produce quality products; to provide industry with trouble-shooting services, to deal with problems encountered in production; and to provide specialized industrial research services for products and production processes. This service, which has been in existence for over 15 years, has been popular with industry and has contributed to substantial improvements in industrial production.

The Board of MBS believes that the full support of government and industry is essential in retaining staff in positions that are difficult to fill, as in the areas of standardization and testing. The Board has therefore put in place specific strategies for the retention of staff for MBS.

5. The situation and role of instrumentation in Malawi

In Malawi, there are many scientific institutions, such as universities, MBS, polytechnic institutes, medical institutions, Government-run agricultural research centres, water development institutes, research institutes, environmental protection research institutes, industrial research and development centres and telecommunications institutes. Those institutions utilize various types of electronic equipment and instruments, both simple and complicated. Since 1964, when Malawi became independent, a great number of those instruments have been acquired, either directly by the institutions themselves or through projects funded by donors.

A national instrument inventory survey showed that Malawi had, over the years, received a large variety of measuring instruments. However, there were no local capabilities for repairing and servicing those instruments. In the 1980s, most of the instruments belonging to institutes were either broken or not in service. In order to solve the problem, repair and maintenance contracts were concluded with the manufacturers. Later, Malawian technicians were trained to provide the necessary services. Neither of those solutions was successful. The national instrument inventory showed that about 50 per cent of the available instruments in various institutions were non-functional. Hence there was a need to establish local capability for providing the needed services on site.

Since Malawi became independent, several programmes had been put in place to develop the country in the areas of science and technology, industry and agriculture in an effort to empower Malawians economically. It was acknowledged that scientific research was a prime element in the creation of wealth, for it brought about an increase in productivity of both labour and capital while ushering in various goods and services of high quality.

In the 1980s, this factor was recognized by several countries in Southern Africa, including Malawi. This prompted partners in development to donate many scientific and electronic instruments to those countries. When the first scientific equipment was being delivered, Malawi was requested to sign servicing and maintenance contracts with the equipment suppliers, who were scattered across the world. At that time, this was viewed as a viable option to maintain the instruments.

Initiatives were made through the National Research Council of Malawi to group the institutions into a team so that they could hire an external engineer who would service the instruments of different users and share the costs. Those arrangements, however, did not work well for a number of reasons. Firstly, the variety of equipment available in those institutions meant that one engineer was not able to attend to all of them, particularly if he was from one equipment manufacturer. Secondly, the cost of the service was very high, as the person had to be flown to Malawi from either Europe or South Africa. The total cost of services therefore became more and more expensive as time progressed because:

- Flight fares, which were pegged to the dollar, were increasing.
- Hotel rates, which were pegged to the dollar, were increasing.
- Car hire was also becoming expensive.
- The cost of the contracts themselves, which was pegged to the dollar, was becoming expensive.
- Occasionally incompetent engineers would be sent, and they would do more harm than good to the equipment.
- The provision of spare parts also became a problem, as the engineer was unable to bring the necessary parts with him.
- The engineer would be from one instrument manufacturer, and he would refuse to service instruments not manufactured by his company.

The arrangement never worked successfully, as the costs become prohibitive and eventually some institutions were unwilling to pay, for two reasons: money was not available; and due to limited time, the service engineer sometimes could not successfully service or repair all the instruments.

In the early 1990s, the idea of sharing costs for service was dropped and the institutions had to pay for the costs individually. By 1991, the national instrument inventory showed that about 50 per cent of the instruments available in various institutions were non-functional, such that most vital functions could not be undertaken locally. In this way, many organizations, such as universities and research

institutions were scaled down. Research activities slowed and in some cases were completely abandoned. Some institutions opted to send the instruments overseas for repairs. This became a very expensive and frustrating exercise, as in some cases the instrument would be sent back without having been repaired; meanwhile, the cost of freight and other expenses had been paid.

Recognizing this situation, the National Research Council of Malawi made efforts to train instrumentation technicians to be responsible for servicing and maintenance. This, however, did not work.

Most institutions, therefore, opted to buy new equipment, as it was almost impossible to service and repair old instruments in Malawi.

The case of the Malawi Bureau of Standards

MBS was hit hard by the situation described above because approximately 50 per cent of its income came from testing and certification. With the breakdown of instruments, some services were suspended and that meant loss of income.

Because of those experiences, there was a call for a redesigning and a rethinking of possible solutions to the problem. MBS, being in the forefront in Malawi as far as scientific measurement equipment was concerned, contacted PTB in Berlin and Braunschweig, Germany, and MTA-MMSZ of Hungary to assist in designing a programme that would develop local capacity and expertise in the servicing and maintenance of measurement instruments. The objective was: to establish an ISSU in the MBS that would serve the whole Malawian economy; and to have a national ISSU that would support the SQAM infrastructure in Malawi and hence support the overall capacity of the economy in its programmes for the development of competitiveness in the global market. Hence, with the initial support of PTB and subsequently that of UNIDO, MTA-MMSZ executed a 12-month project, starting on 1 August 2002.

6. Identification of the premises of the Instrumentation Support Service Centre

The starting conditions in MBS were assessed at the beginning of the implementation. It can be stated that MBS started from zero level.

The ISSU of MBS was planned as a separate unit to operate on a cost-centre basis, and as such the selection of premises was important to the success of the project. On the recommendations of the project manager from MTA-MMSZ, who designed the required housing, considering the work requirements, suitable conditions and the necessary infrastructure, the location was selected in cooperation with MBS management from among the existing buildings and laboratories of MBS. The building for the ISSU included the following:

- *Workshop for repair and maintenance (for two engineers)*: A room in the MBS materials laboratory (size (in metres): about 3.5 x 2.8 x 2.5) was selected for this purpose. The laboratory may be extended if the facility grows in the future. The minimum tools and measuring instruments that are necessary for repair work were to be provided from the income of the repair activity.

- *Storage room*: The older pesticides formulation chemical storeroom (size (in metres): about 3.8 x 3.5 x 2.7), near the workshop (without windows), was chosen to be used for storing faulty and repaired measuring instruments, which are used for the repair activity, and the documents of the service activity. At the same time, the room is used to store technical documentation, records of the unit and the library for technical material of the consultancy unit.

- *Cleaning room*: A room behind the MBS material laboratory (size (in metres): about 2.3 x 1.5 x 2.1) was selected as a cleaning room, which is needed during the repair work. The cleaning equipment (vacuum cleaner, utensils for washing etc.) and compressor were to be provided by MBS from its own resources.

- *Consultancy room of the ISSC*: A room in the MBS pesticides formulation laboratory (size (in metres): about 4.1 x 2.5 x 2.7) will be used for operating the Malawi Electronic Equipment and Scientific Instrument Registry (MEESIR) and for providing consultancy services to customers. At the same time, the personal computer workstation can be used by the ISSU. During the implementation of the project, the experts at the site could use this room, too.

The selection and appointment of the technical staff and the heads of units (the ISSU of MBS and the consultancy unit) from among the MBS staff were carried out by MBS managers, who also took into consideration the advice of the MTA-MMSZ project manager regarding qualifications, tasks, functions and responsibilities.

7. Malawi Bureau of Standards: Strengths, weaknesses, opportunities and threats

MBS as a national bureau of standards has certain strengths and weaknesses that need to be taken into account in its planning processes, and its project design and execution. A strength, weakness, opportunity and threat (SWOT) analysis of MBS is summarized below.

(a) Strengths

The legal framework and infrastructure

MBS was established by the enactment by Parliament of the Malawi Bureau of Standards Act, of 1972. The Act gives MBS a mandate to operate and promote quality and standards in Malawi. As a corporate body and a national organization, it has the privilege of being heard by all stakeholders and the donor community, and has the full backing of the Government.

MBS is represented in and is recognized by regional and international organizations for standardization. It is a member or associate member of the following organizations:

- Expert Group on Standardization, Quality Assurance, Accreditation and Metrology for SADC
- Committee on Standardization and Quality Assurance of the Common Market for Eastern and Southern Africa
- African Regional Organization for Standardization
- ISO
- International Electrotechnical Commission
- International Organization for Legal Metrology

In addition, MBS is the Government's designated National Enquiry Point for WTO (the Agreement on Technical Barriers to Trade and the Agreement on Application of Sanitary and Phytosanitary Measures) in Malawi; and the Codex Contact Point responsible for national Codex matters in Malawi.

MBS has infrastructure that has been put in place through investments made by both the Government and donors over the years since 1972. It also has the support of the private sector in its programmes. MBS has therefore firmly established itself and its programmes in Malawi.

Since 1990, MBS has been using a project approach in the implementation of its programmes and creating cost centres aimed at making them sustainable. This approach has worked very well in a number of programmes and has enabled MBS to steadily reduce its financial dependence on public funding from 50 per cent in 1996 to less than 5 per cent in 2003.

One important aspect of the strengths of MBS is the professional, scientific and technical expertise that its staff has developed over the years. MBS expertise represents over two decades of knowledge and experience in all matters of standardization, quality assurance, accreditation and metrology. MBS has built its reputation at the national, regional and international levels.

(b) Weaknesses

There are however a number of weaknesses that the organization needs to address as it implements its programmes. Firstly, the MBS programmes and infrastructure were grossly underfunded, particularly in the early years of its existence. As a result, the organization has been struggling to effectively deliver some of its programmes and services.

Secondly, there have been problems associated with the MBS legal framework and provisions. The original law under which it was established was enacted in 1972 and, although there have been amendments to it from time to time, those amendments have not been in line with the socio-economic developments in the country. As a result of this, the law itself is outdated. The implementation of its provisions presents problems.

There has also been close control by the Government of human resources matters, to the extent that the remuneration packages, which must have government approval, are no longer those of a competitive organization. This has tended to impose serious constraints on attempts by management to motivate the staff operating the programmes. It has also led to sizeable staff turnover. There must therefore be constant recruitment and training of staff in order to maintain the programmes.

There is a low level of human resource productivity in the Malawian economy, a fact that has been described in a number of publications as an economic constraint. This has also affected MBS, despite efforts by its management to make it a lead organization in terms of productivity.

(c) Opportunities

MBS, being a national organization for standardization operating under the laws of Malawi, has the possibility of reviewing its mandate and legal framework in order to update its position and strengths. This can be done in two ways: by amending or designing new regulations that can be published by the Minister of Commerce and Industry directly in order to regulate or monitor SQAM activities more effectively at any time; or by submitting amendments or new laws to Parliament so that the legal regime is modified or strengthened.

Over the years, the whole issue of SQAM in the Malawian economy has been viewed with more understanding by MBS clients. There is now more demand for the activities as industry realizes that the consumer is demanding more quality and that the external market has higher demands on requirements. The players in industry are now demanding more and more services from MBS in all areas of SQAM. This presents great opportunities for the growth of SQAM and related activities in the Malawian economy. The general issues of global competitiveness have also resulted in increased demand for SQAM activities.

There has been increased awareness of the importance of SQAM among government and public institutions in the Malawian economy. There is therefore more collaboration between MBS and

government ministries and departments and public institutions. The development of national standards and quality programmes has seen more participation from the public sector in recent years.

(d) Threats

Players other than MBS have emerged in the area of SQAM. Private companies have started offering competitive services in quality assurance, certification and metrological services. Among these are national organizations for standardization in other countries, such as the South African Bureau of Standards and the Standards Association of Zimbabwe, which have started offering quality management systems certification to Malawian industry. Foreign companies have also been in direct competition with MBS, offering the industry services in calibration of measuring instruments and related activities.

Another possible threat is the competitiveness of the labour market. MBS must keep training its staff in the specialized areas of SQAM in order to maintain its professional edge. Industry requires from time to time similar expertise; however, since they do not carry out any training, MBS-trained staff keep drifting to the private sector. It is difficult to compete with the private sector on the labour market.

MBS management and selected technical staff considered it to be essential to solve the problem of missing technical services, as such services are important for the safe operation of sophisticated precision measuring instruments. The management and staff are conscious of the magnitude of the problem, which affects both MBS and its customers in the quality systems in Malawi. They are ready to accept the advice of the international experts and adapt it to the Malawi experience.

Regarding the ISSU of MBS, the results of the SWOT analysis at the beginning of the project are summarized in figure V.

Figure V
Analysis of strengths, weaknesses, opportunities and threats at the beginning of the project

Strengths	***Weaknesses***
MBS management	No designated laboratories for the services, which are needed for the safe operation of the sophisticated, precision measuring instruments
MBS management	No technical staff for providing technical services
Continuous analysis of priority needs, to be able to focus efforts, which were limited at the beginning	Large quantity and variety of faulty instruments both in MBS and among customers
Use of income from the repair activity, carried out during the first special training, for the acquisition of the minimum tools and instruments	No tools and measuring instruments, which were needed for the repair activity
Qualified MBS operators of precision measuring instruments	Lack of expertise of repair engineer in the operation of sophisticated precision measuring instruments
Establishment of contacts with manufacturers' service representatives in South Africa	No technical background (technical documentation, service documentation, spare parts), which was needed for the repair work
MBS management	No operation of the cost centre
MBS management	Lack of a special incentive system

Opportunities	*Threats*
Existing laboratories with all the necessary infrastructure, which could be selected according to the requirements of the missing services	Other services may suffer from losing their laboratory space for the ISSU of MBS
Cooperation with selected experts in MBS and carrying out the recruitment of necessary engineers	The operator of scientific measuring equipment during the cooperation with the repair engineer are under double supervision
Collating of technical specification of measuring instruments of customers throughout the whole country	No continuous updating of the database
Possibilities in the domestic market for acquiring the tools and measuring instruments necessary for the repair work using own resources	Lack of sufficient tools and measuring instruments
The manufacturers' service representatives in South Africa were ready to cooperate with MBS under business conditions	The continuous, flexible contact may suffer because of a lack of updating activities
Possibilities in retaining qualified staff both in the ISSU of MBS and in the case of cooperating operators of precision measuring instruments	The successful operation of the cost centre may increase the difference between MBS and other units
Possibilities for developing and expanding the services provided for MBS and outside customers	Loss of trained technical staff

D. Situation at the end of the project

1. Operation of the instrument registry

The consultancy room was cleaned and painted and the furniture was provided by MBS, as advised. The personal computer workstation was acquired by MBS according to schedule and as specified by MTA-MMSZ.

MBS management formed a group of experts to operate MEESIR and provide the consultancy services to customers and the head of the unit was also appointed according to the MTA-MMSZ project manager's advice.

The computer-based instrument registry was adapted by MTA-MMSZ to the requirements in Malawi, and MEESIR was developed. MEESIR was successfully installed in the MBS personal computer workstation. During the installation, hands-on training was provided for the selected MBS experts.

The MBS team followed the instructions of the MTA-MMSZ experts and began to update the technical data of the precision measuring instruments of the customers using the registration forms, and this work has been continuously carried out since then.

During the hands-on training, the data of 139 measuring instruments of different suppliers were loaded into the database. The data of measuring instruments of several customers in Malawi were collated by MBS. Using those data the evaluation of priorities is continuously being updated in order to focus efforts for providing efficient instrumentation support services to customers. Those data will be updated regularly. The understanding by the process team of the operation of MEESIR and the results of the training were evaluated.

The staff has begun to collate the technical material (leaflets, operation manuals, circuit diagrams etc.) obtained by MBS, including from its customers. MTA-MMSZ provided technical material for MBS free of charge to enable it to begin the establishment of a library of such material. The ways to collate technical material obtained from the manufacturers and through the Internet were explained and training was given during the missions of the MTA-MMSZ experts. The on-line connection of the PC workstation to the Internet was provided by MBS. The connection can also be used by the ISSU of MBS.

In order to enable the continued operation of MEESIR in Malawi, practical suggestions and recommendations were made. One of the most important tasks is to invite representatives from research institutes, universities, and governmental and private companies to join in the registration. Another important activity of MEESIR's future operation is the establishment of administrative procedures and an operation schedule. Another important task is the effective management of the user community, including the determination of priorities and privileges, regular analysis of the users' demands and publicizing the services of MEESIR. This work will be carried out by the data processing team of MBS and will be tailored to the specific local conditions.

As far as the establishment of the library of technical material is concerned, the team must develop a database of technical material in order to be able to control its usage.

According to the experience of the subcontractor, the best way to get private companies interested in the registration is to establish an expert consultancy service, which can generate interest among companies in the registration. It was proposed that the use of the consultancy service be provided at a less expensive rate or free of charge to those companies which register their instruments or equipment with MEESIR.

MEESIR is an essential tool for the management of institutions, in analysing problems of precision measuring instruments in Malawi and identifying the priority order of dealing with the problems, in order to be able to focus efforts. In the later phase, MEESIR can also assist in working out the purchase policy for customers or for large organizations (ministries, universities etc.).

MEESIR can be used to provide consultancy for technical questions from customers and also engineering. In this way, MBS can have a significant impact on the development of the measuring culture in Malawi (quality control, health services, higher education, agricultural research etc.).

2. Operation of the cost centre

After considering the recommendations of the project manager of MTA-MMSZ, some reorganization of the rooms was carried out. Major work was done on the storage room, which required some openings to be blocked off and the installation shelves for the storage of equipment, parts and documents for the ISSU.

The cleaning room also required some modifications: a proper window needed to be installed and some refurbishing was needed for that purpose. The idea was to rearrange the existing facilities in such a way as not to spend too much of the resources on the preparation of the areas to be used for the ISSU project.

All work such as cleaning and renovation and the acquisition and preparation of furniture (workbenches, shelves etc.) was undertaken by MBS using its own resources.

It became necessary for MBS to procure some basic tools for the project, both in Malawi and abroad. The Hungarian experts made a recommendation on the type of tools that would be required. A set of tools, identified and recommended by the experts, was acquired by MBS using its own resources and using income from the ISSU activities. However, due to the initial limited funds, not all of the items

on the list were procured in the first year. Those items included an oscilloscope, which is considered essential for diagnostic work.

An urgent task right at the beginning was the selection of staff for the project. From among the existing staff, persons were identified who had suitable qualifications and skills and who were deemed trainable. However, there was a need to recruit a person specifically qualified to handle high-tech tasks. For this reason, a recruitment exercise was carried out with the cooperation of one of the MTA-MMSZ experts who was responsible for training staff. The following key steps were taken: (a) the requirements for the position were drawn up and vetted by the MTA-MMSZ expert; (b) the position was then advertised and short-listed candidates were invited for an interview; and (c) the interview was then conducted together with the expert, in order to enable him to participate in the selection of a suitable candidate for the position.

Having followed the above steps and identified the candidate, a team of five people, including the leader, was then established. It is worth mentioning that the team included one woman.

Training of the team members was conducted in two parts. Part 1 of the training took place on the premises of the ISSU of MBS in Blantyre, Malawi. The training expert from Hungary was attached to the unit and practical training of the team of five was carried out using scientific equipment to be repaired, first from MBS and later from clients. The equipment was dismantled completely and reassembled with the help of the expert. The second part of the first training was then conducted in South Africa under the supervision of the Hungarian expert. This part was split into training at the National Metrology Laboratory of South Africa and establishment of contacts with the manufacturers' service representatives in South Africa in order to have the necessary technical background for the repair activity under business conditions.

In the second part, during the second special training, control of the tasks of the first special training was also carried out. The repair tasks—in those cases where the necessary spare parts were available—were finished by staff of the ISSU of MBS. The evaluation of the order of priority of the requirements was carried out before each training. Just before the second special training, an aggressive advertising campaign was carried out by MBS. Several new requirements for repair activity were discovered and a lot of new repair work could be started under the supervision of the senior consultant.

Each analytical instrument selected was introduced to explain the operation before the trouble-shooting started. At the block diagram level, the main functional units of the instruments and the most frequent malfunctions caused by the units were explained. Further exercises were carried out on determining the limitations of instruments, on finding solutions, and on finding out how to obtain technical assistance from the closest representative.

During the repair of the selected measuring instruments, the MBS repair engineer and the technicians were trained on how to communicate with customers, and how to understand their problems and try to solve analytical problems not related to any malfunction but rather poor knowledge of instrument usage. They were also trained on how to get useful information about the operation of the precision measuring instruments from the customers.

The team was also trained on how to start and perform trouble-shooting with the selected measuring instruments. They were instructed also on how to find a solution, how to get technical help from the representatives in South Africa, and how to use the connections established during the first special training course, if possible. Communication through e-mail was discussed. Careful dismounting without damaging the instruments was taught. Staff members were instructed on how to find the available documentation and how to use it in the most effective way. They also learned how to remember and mark different parts during dismounting to make the reassembling procedure simple and safe, which are the first and most logical steps to take when looking for the fault. It was also

explained how to identify the problem and to describe it in a proper technical way in order to be able to get technical support through e-mail.

During the special training courses, which were carried out in those laboratories where the faulty measuring instruments were repaired, if necessary, the importance of the continuous activity was highlighted, and the future tasks of the ISSU were explained.

Immediately, during the on-site training, repair work began. As the database of clients was being developed, the repair work began on equipment owned by MBS that was not functioning prior to the start of the project. That was followed by repair work on instruments owned by clients, mostly on-site repair work.

As advised by the MTA-MMSZ project manager, the ISSU of MBS was planned to operate as a separate cost centre within MBS. That means that all its activities are separate from those of other MBS programmes, both administratively and in terms of their financial management. All paper work for the ISSU must be distinguished as such with stamps for the ISSU. The external and internal forms—which were necessary in keeping proper records of the repair work—were developed jointly by MBS and MTA-MMSZ experts. Financial reporting must be done separately so that there is the possibility of drawing up separate income and expenditure accounts at the end of each quarter and each year.

As an MBS cost centre, it is therefore subject to management review every quarter after the administrative and financial reports are received. During the period from August 2002 to August 2003 the ISSU of MBS operated as a viable cost centre.

The practical value of the precision measuring instruments repaired by the ISSU of MBS during the period from October 2002 to August 2003, was about US$ 130,000. The present value of the measuring instruments, which can solve the above-mentioned measuring tasks, is approximately US$ 400,000. This calculation reflects neither the value of the measurements, which are carried out with the repaired measuring instruments, nor the effects of the measurements on the work of the customers. The first analysis shows that the cost of repairs is negligible compared with the cost incurred by the precision measuring instrument not being in operation.

3. Strengths, weaknesses, opportunities and threats at the end of the project

(a) Strengths and opportunities

The project plan included an examination of the strengths of the ISSU activities in the next phases. The main basis for this is the fact that the establishment phase has already been very successful and has laid the foundation for the development of the next phases. This in itself is vital and is one of the strengths of the project. The support that is being received from UNIDO, PTB, the UNDP office in Lilongwe, government ministries and the scientific and industrial institutions in Malawi is in itself a strength.

The links established with the suppliers of instruments is also a strength. Those links and relationships are invaluable to the viability of the ISSU of MBS.

It will be important also to maintain the relationship already established with external institutions. First, the relationship with MTA-MMSZ of Hungary needs to be maintained, as well as that with the individual Hungarian engineers and experts who have assisted in establishing the project during its first phase. The relationship established with the National Metrology Laboratory of the Council of Scientific and Industrial Research of South Africa also needs to be maintained, as does the cooperation with NUSESA. Those contacts will be important in providing support and are elements of the strengths of the project plan.

(b) Weaknesses and threats

The project plan has to take into account possible weaknesses and threats that might adversely affect the further development of the activity and its sustainability. Any failure to retain the engineers will seriously affect the project. Proper management is crucial, and special attention must be given to the relationship that is being built with clients and interested institutions.

The results of the SWOT analysis at the end of the project are summarized in figure VI.

Figure VI
Analysis of the strengths, weaknesses, opportunities and threats at the end of the project

Strengths	***Weaknesses***
MBS management	Need to expand the technical staff providing technical services
Continuous analysis of priority needs, to be able to focus efforts, which were limited at the beginning	Large quantity and variety of faulty instruments both in MBS and among customers
Use of income from repair activity; finding further donor support to be able to acquire the necessary tools and instruments	Not enough tools and measuring instruments, which were needed for the complicated repair activity
Qualified MBS operators of precision measuring instruments	Lack of expertise of repair engineer in the operation of sophisticated precision measuring instruments
Development of contacts with manufacturers' service representatives in South Africa	Not enough technical background (technical documentation, service documentation, spare parts), which are needed for the repair work
MBS management	Insufficient operation of the special incentive

Opportunities	***Threats***
Existing laboratories with all the necessary infrastructure, which could be selected according to the requirements of the missing services	Other services may suffer from losing their laboratory space for the ISSU of MBS
Cooperation with selected experts in MBS and carrying out the recruitment of necessary engineers	The operator of scientific measuring equipment during the cooperation with the repair engineer is under the supervision of two different supervisors
Collating of technical specification of measuring instruments of customers throughout the whole country	No continuous updating of database No priority order of requirements
Possibilities in the domestic and foreign markets for acquiring the tools and measuring instruments necessary for the repair work using own resources and outside funds	Lack of sufficient tools and measuring instruments
The manufacturers' service representatives in South Africa are ready to cooperate with MBS under business conditions	The continuous, flexible contact may suffer because of a lack of updating activities
Possibilities in retaining qualified staff both in the ISSU of MBS and in the case of cooperating operators of precision measuring instruments	The successful operation of the cost centre may increase the difference between MBS and other units
Possibilities for developing and expanding the services provided for MBS and outside customers	Loss of trained technical staff

4. Business plan to be followed

The goal for the ISSU of MBS is to become the national and regional centre for the servicing and repair of scientific measuring instruments within the next year. This goal is to be achieved in two phases, with the national goal being achieved and consolidated first.

The mission of the ISSU of MBS is to provide professional and self-sustaining services in the area of scientific instrumentation support services in order to fully support the development of standardization, quality assurance, accreditation, metrology and scientific research at the national and regional levels.

The development of the service will evolve from the founding stage, which covered the period from August 2002 to August 2003, to the second phase, which will see the consolidation of the facilities and operations, the promotion of the service among its clients and the strengthening of the workshop facilities to cover more advanced scientific instruments. To this effect, the second phase will call for additional donor financing in the areas of training additional staff (engineers and technicians) and more specialized training to cover the more sophisticated instruments. This phase will also cover the strengthening of the workshop facilities to cover the more sophisticated measuring instruments of the unit that are required for more complicated repair activities.

The full development of the MEESIR database is also the objective of the first phase. This will take two turns, the first being the completion of the data for national instruments and users and the second being the input of data from the regional instruments and users initially with the cooperation of NUSESA, which has already been initiated following the discussion between the management of the ISSU of MBS and the Secretary-General of NUSESA during IMEKO Congress 2003, held in Cavtat, Croatia, in mid-2003.

The development of personnel (the recruitment of another full-time electronic engineer using MBS resources is planned) to manage the ISSU of MBS will receive special attention, the objective being the achievement of an optimum level of operation and retention of the staff as part of the strategy for the sustainability of the ISSU.

The promotion of the ISSU of MBS as a special subprogramme will also be undertaken in the second phase. This will be a continuation of the launch conducted at the end of the first phase, which was done successfully with coverage by the radio, print and television media. This start will be capitalized on with special promotional material produced for distribution to existing and potential clients, including regional clients; the promotion will be carried out together with NUSESA. The ISSU management has already reached an agreement with the Secretary-General of NUSESA to include ISSU service information on the NUSESA website.

Financially, the ISSU management will continue to endeavour to ensure the sustainability of operations. A special staff motivation scheme will be introduced that will be innovative and attractive in order to retain the existing staff.

The future of the project looks bright. It has the possibility of developing into a full regional programme that will support scientific and industrial development and be a backbone for the competitiveness of the economies in the regional and global markets. It is planned for the ISSU of MBS to reach self-sufficiency in 3-4 years.

E. Evaluation of the project

1. Selected method of evaluation

The ISSU of MBS is providing instrumental support services for MBS itself and outside customers. In the first phase, the services include consultancy, repair and maintenance services.

In the first period it is advisable to provide the consultancy services free of charge. At the same time these services enable MBS to develop MEESIR, as the customers are interested in supplying the technical data of their idle and operational precision measuring instruments, because they can also get information from MEESIR regarding other measuring instruments.

Economic calculation

The ISSU of MBS is providing repair and maintenance services. The main features of those services are as follows:

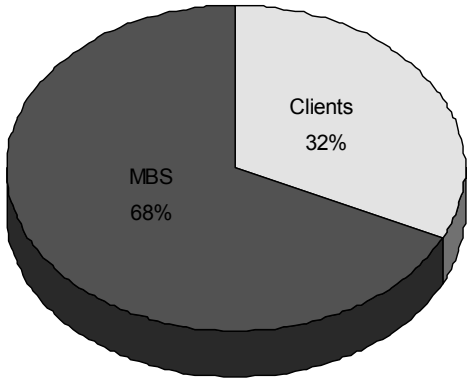
- *Use value of measuring instrument*. This value depends on the age of the measuring instrument (30-50 per cent of the purchase value).
- *Present value of the measuring instrument*. This value is the present purchase value of that measuring instrument which can provide the required measuring task.
- *Loss of idle time*. This is a summary of the value of those measurements which could not be carried out during the idle period.
- *Direct income*. This is the MBS income paid by outside customers for the MBS repair activity.
- *Internal income*. This is a summary of the value of the repair activity provided for MBS; these figures are recorded on the internal account of the ISSU of MBS.
- *Expenditure*. These are the costs of repair paid by the ISSU of MBS (salaries, spare parts, transport, allowances, acquisition of tools and measuring instruments, renovation).

2. Evaluation of the activity of the Instrumentation Support Service Unit of the Malawi Bureau of Standards

In the economic evaluation, these values can be calculated and report the sustainability of the issue of MBS.

The first analysis of the costs and expenditures during the period from September 2002 to August 2003 shows that total income of US$ 9,320 was generated. This sum contains the direct income (32 per cent, paid by the customers) and MBS internal income through the repair of MBS equipment (68 per cent) (see figure VII). Total expenditure, which contains the cost of a minimum repair tool kit, salaries, spare parts, transport, allowances and renovation of the workshop result in total expenditure of US$ 4,800.

Figure VII
Income distribution of the Instrumentation Support Service Unit, September 2002-August 2003



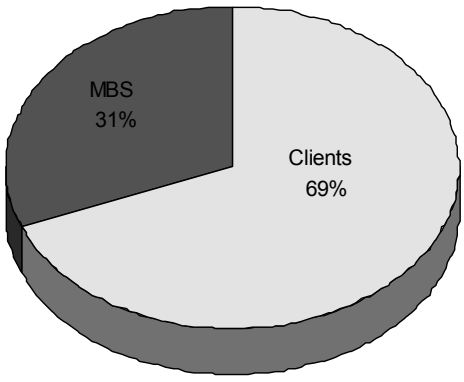
Source: Malawi Bureau of Standards (MBS).

The result of this calculation shows that during the period a surplus of US$ 4,520 was generated by the ISSU of MBS

The second analysis of the costs and expenditures during the period of July 2003 to June 2004 shows that total income of US$ 5,400 was generated. This sum contains the direct income (69 per cent, paid by the customers) and MBS internal income through the repair of MBS equipment (31 per cent) (see figure VIII). Total expenditure amounted to US$ 2,980.

The result of this calculation shows that during the period a surplus of US$ 2,420 was generated by the ISSU of MBS.

Figure VIII
Income distribution of the Instrumentation Support Service Unit, July 2003-June 2004

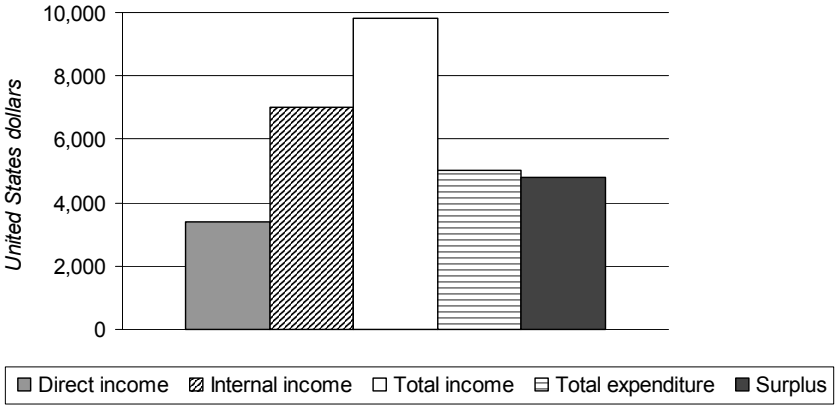


Source: Malawi Bureau of Standards (MBS).

Comparison of the two periods shows the considerable ability of the ISSU, not only to offer the services within MBS but also to retain clients in the educational, social and industrial sectors. Income

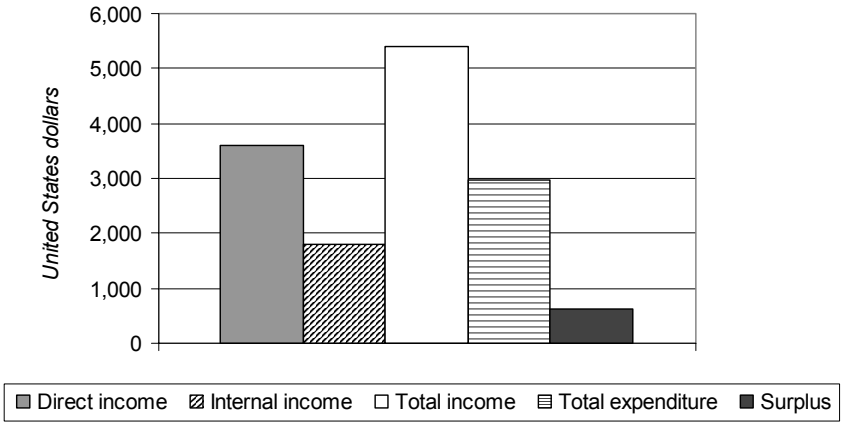
in the period from September 2002 to August 2003 was mainly internal income generated through payment of (see figure IX), MBS. The income distribution was the reverse for the period from July 2003 to June 2004, with external income amounting to 69 per cent (see figure X).

Figure IX
Income and expenditure, September 2002-August 2003



Source: Malawi Bureau of Standards.

Figure X
Income and expenditure, July 2003-June 2004



Source: Malawi Bureau of Standards.

The sum of the surplus does not contain the added value and the social impact on the customers and/or users (if MBS owned the measuring instrument that was repaired, MBS is also considered to be the customer) of the repair and maintenance activity.

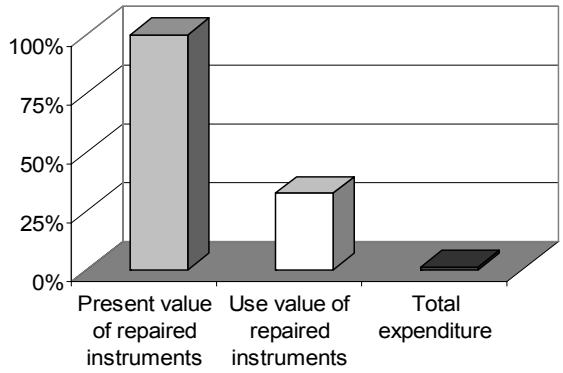
(a) Added values

After the repair of a precision measuring instrument, the owner can use it to carry out the intended measuring tasks. In this way, no new investment in the present value of the precision measuring instrument is needed if the owner of the instrument wants to carry out the required measuring task, which may cost considerable amounts (and in many cases the required funds are not available).

The owner can continue providing measurements to its customers. The production value of the measurements paid by the customers to the owner can increase the owner's turnover, instead of incurring a loss during the idle period.

The measurements provided by the owner of the instruments are needed either for the operation of a technology (in industry or agriculture) or for the quality control of a product etc. Successful repair and maintenance activity of precision measuring instruments affect the operation of complex production lines, technologies in industry and agriculture, the value of which amounts to many times the use value of measuring instruments and the repair costs (see figure XI).

Figure XI
Present value and use value of repaired instruments



Source: Malawi Bureau of Standards.

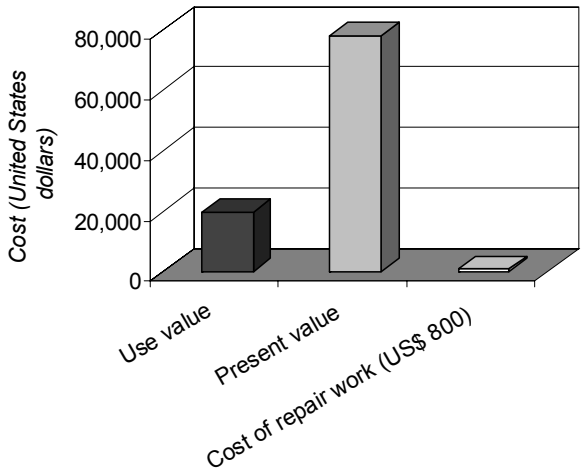
(b) Social impact

The operation of the measuring instruments has several beneficial effects for the owner and for society that sometimes cannot be expressed only in terms of money; however, those effects are more important than the value of the measurement.

Controlling the values of hazardous substances in pharmaceutical and agricultural products and fertilizers improves the health of consumers.

Being able to control the quality of water on a regular basis decreases the infection rate of human diseases, as well as animal diseases, caused by contaminated drinking water (see figure XII). The water supply for 540,000 inhabitants of the Blantyre area in Malawi could not be controlled for three years. Estimated water loss through lack of control in 2000 was 283,000 per square metre.

Figure XII
Water diagnostic equipment

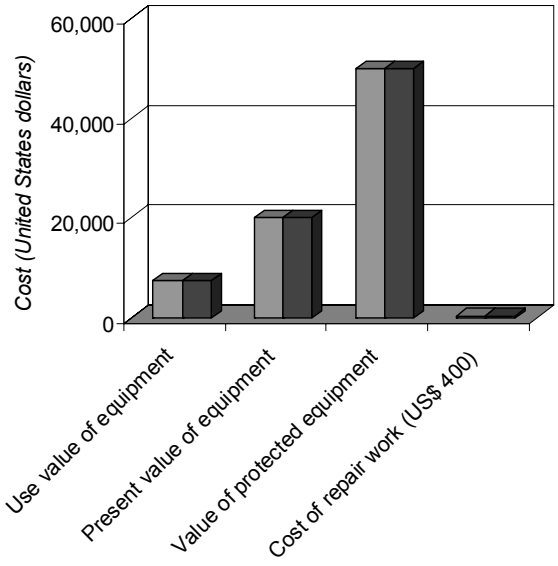


Before the repair work was carried out, there was no control of Newcastle disease in the field and, as a result, chickens died in masses. Before the repair work, there was limited vaccine production and the diagnostic work necessary for the development of the proper treatment for the sick chickens could not be carried out.

Life-threatening situations for patients in hospitals resulting from the malfunctioning or breaking down of emergency equipment can be prevented, which is reassuring for the patients.

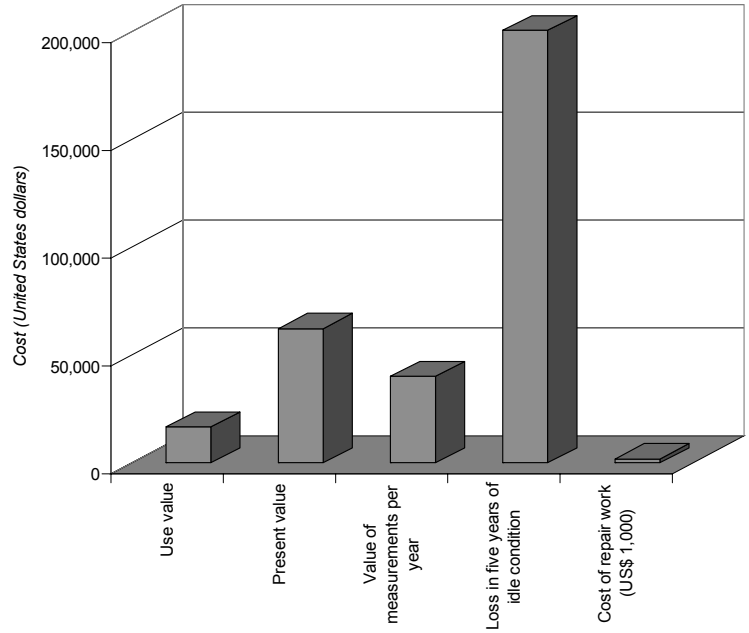
From the date on which the equipment became idle (8 December 2002) to the repair date (13 May 2003), no backup facility was available for the backup emergency power system of the hospital. The cost of repairs to solve the problem was only $400 (see figure XIII).

Figure XIII
Hospital equipment



Equipment requiring repairs can have an impact on education and on the availability of a professional workforce for the economy. Students could not acquire practical analytical skills for five years during their studies at the Malawi Polytechnic (see figure XIV). No samples could be analysed for environmental control by the Malawi Polytechnic and no minerals in plants, animal tissue, soil or water could be analysed. This led to considerable problems related to animals and plants; in some cases, the animals or plants died.

Figure XIV
Equipment of the Malawi Polytechnic



Being able to control the stock feed for several companies and the production process makes it possible to take action in the early stages of production and thus prevent profit losses or health hazards. The faulty operation of a centrifuge in a veterinary laboratory may influence vaccine production and lead to incorrect treatment of sick animals.

Lack of measurement results may increase the potential of human toxication and the loss of confidence in products.

F. Possibilities for replication

As a result of the survey financed by PTB in 1999, the bureaux of standards of the countries can be selected as possible partner institutes. Those institutes have endeavoured to ensure the continued smooth functioning of the manufacturing and service sectors of the industry in their countries by developing standards and offering testing and inspection facilities and carrying out the independent qualifying activity needed in industrial and agricultural production and the importation of goods into the countries. They also try to improve choice, safety, quality and compatibility in purchased and produced goods and services. The institutes have worked continuously to facilitate trade by specifying minimum requirements for products and services for local and foreign markets. They provide calibrating services linked to national primary standards for the quality control laboratories of the production firms and educate industrialists on how to develop standards and how to carry out quality control measurements. In this way, the institutes have close contact with industry and agriculture in their countries. At the same time they have laboratories with the necessary infrastructure to enable them to establish ISSC. The institutes employ in their testing departments

scientific operators of precision measuring instruments who are able to provide the necessary cooperation of the repair engineers and technicians.

If the suitable management and the necessary funds are available, the design of the first phase (considering the experience in the implementation of the ISSUs of KEBS, MBS and the Standards Organisation of Nigeria) of further local units can start. Every country needs a local unit for providing instrumentation support services. However, those local ISSUs, which are operating in a sustainable manner, should form the basis for the implementation of local units in neighbouring countries in the region (see the section entitled "Regional aspect of the development of instrumentation support services").

Cooperation should be developed between them in order to exchange information and experiences, provide management training on successful practices of local units and build up technical expertise under business conditions.

In this context, the efficient use of national instrumentation resources is one of the most important prerequisites for economic development, as the instruments represent a considerable part of the national wealth. It has been shown that the effective operation of the instrumentation infrastructure is an essential element of economic development. The smooth operation of systems in areas such as metrology, quality control, testing, environmental monitoring and control and laboratories in the areas of industry, agriculture, education, research and public health—in any area where measuring activities are applied—need adequate instrumentation services.

Developing countries and countries with economies in transition vary considerably in their level of development, economic systems and market environments. Despite this diversity, they share a number of common features. One of these is insufficient instrumentation infrastructure.

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Printed in Austria
V-05-87613—November 2005—500

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