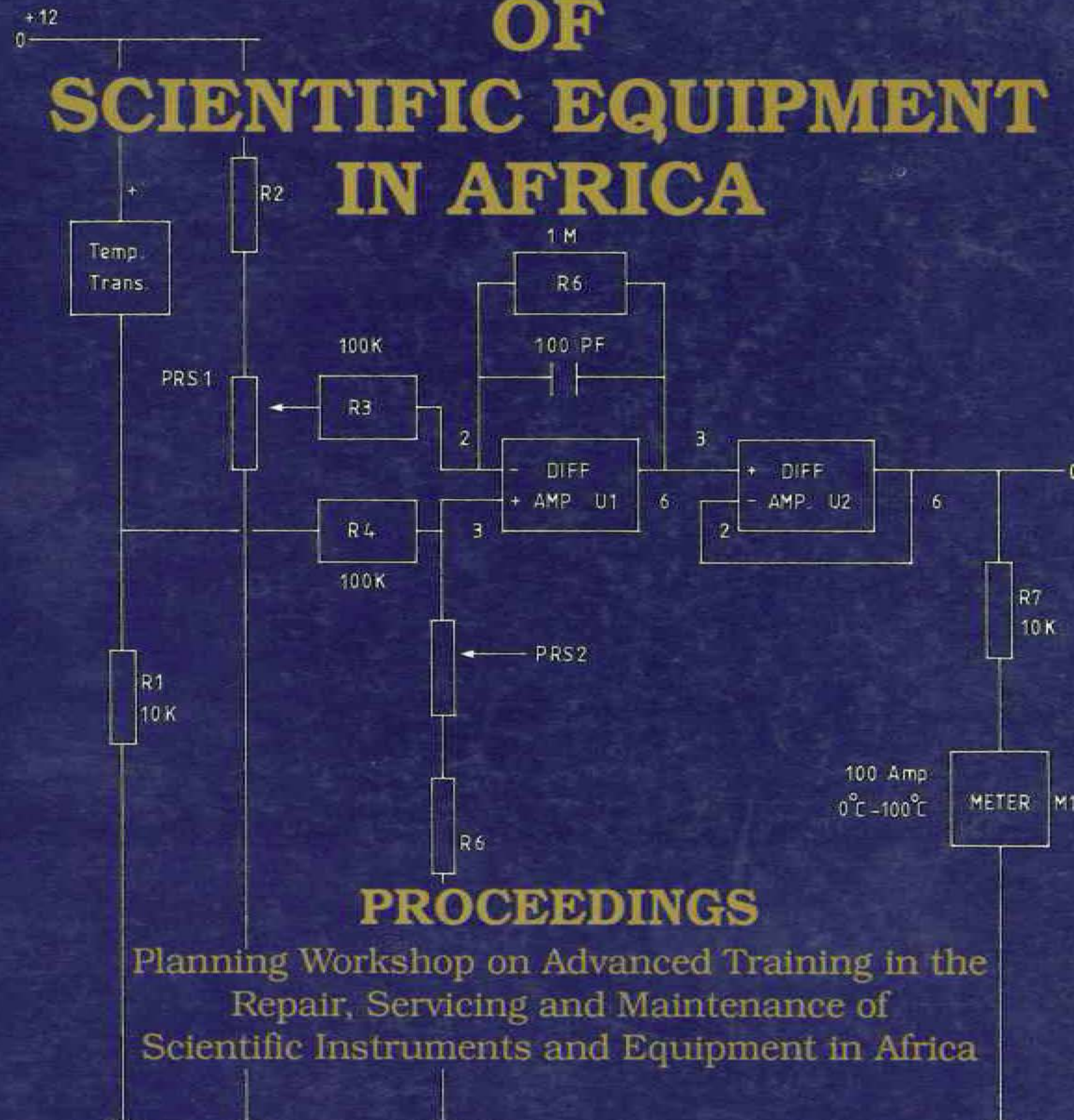
TRAINING IN MAINTENANCE AND SERVICING OF SCIENTIFIC EQUIPMENT IN AFRICA



PROCEEDINGS

Planning Workshop on Advanced Training in the Repair, Servicing and Maintenance of Scientific Instruments and Equipment in Africa

International Centre of Insect Physiology and Ecology (ICIPE)
Nairobi, Kenya

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PROCEEDINGS

of the

PLANNING WORKSHOP ON ADVANCED TRAINING IN THE REPAIR, SERVICING AND MAINTENANCE OF SCIENTIFIC INSTRUMENTS AND EQUIPMENT IN AFRICA

ICIPE WORLD HEADQUARTERS, DUDUVILLE, NAIROBI, KENYA

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Foreword

If one were to define the difference between the countries of the South and those of the industrialised North, the principal distinguishing feature of the latter is, arguably, their higher level of technological development. Science and Technology (S&T) is the engine that drives the design and application of efficient telecommunications and transport systems, electronics, the mechanisation of agriculture, building and construction, medical equipment and facilities, improved energy use and generation — indeed every practical and material facet of modern life. But effective application of S&T and its research and development (R&D) components is firmly based on the instruments and equipment that are used in detection, identification and measurement, parts design and manufacture, quality control and systems integration, as well as for the multifarious activities of fundamental scientific research.

This Workshop is the first pan-African effort of its kind initiated by an institution based in Africa, to address the serious instrumentation problems affecting S&T development on the continent as a whole. The ICIPE, in collaboration with the Government of Kenya, and funded by UNDP, organised and conducted this Planning Workshop to discuss, among other issues, the problems of procuring, repairing and maintaining scientific equipment.

Also discussed were the modalities of establishing Instrumentation Centres for advanced training in the repair and servicing of such instruments, as well as training in their design, development and modification to the often unfavourable operating environment found in African countries. The experiences of successful Instrumentation Centres in Brazil, Morocco and Hungary were presented as potential models for such an exercise.

Networking of the Instrumentation Centres in the region and collaboration with national research institutions were considered by the Workshop the as means of most effectively utilising the limited instrumentation resources available.

The Observations and Recommendations of the Workshop, reported at the end of these Proceedings, contain a plethora of concrete suggestions for solving the problems of disrepair, disuse and wastage of equipment that ultimately hinder the technological advancement that Africa must achieve for itself.

OPENING ADDRESS

OPENING ADDRESS

Hon. Prof. S.K. Ongeri, M.P.

Minister for Technical Training and Applied Technology, Kenya

(Read by Prof. Karega Mutahi, Permanent Secretary)

Allow me to thank the International Centre of Insect Physiology and Ecology who, with the generous support from the United Nations Development Programme, have made it possible to hold this Workshop. As the Minister for Technical Training and Applied Technology, I am grateful and proud that such an important workshop has been convened on Kenyan soil through the initiative of the African people themselves.

You are gathered here to deliberate on a very import aspect of technical training, which is the repair, servicing and maintenance of scientific equipment in Africa. We all know that rapid technological development depends upon the condition of scientific equipment and instruments.

As you are aware, technology is one area which is subject to rapid innovations and inventions, especially in the field of instrumentation. It is not uncommon to find new products being considered obsolete by the time they are launched onto the market. Even with the best background of training, it is not easy for one to maintain technical competence without constant upgrading of skills in the latest technologies and techniques in his/her area of specialisation. The theme of your Workshop is therefore, very appropriate and fitting to the circumstances pertaining to the African continent.

The state of disrepair, disuse and wastage of scientific instruments is a problem affecting Africa as a whole. Since independence, most African governments have allocated a large proportion of their budget to the education of their people. Many engineers and scientists have been trained, but their work has been hampered by lack of proper exposure and access to modern equipment.

This nightmare is further deepened by the varieties of models, equipment and instruments that have been acquired through donations or through direct purchase schemes. It is not unusual to find moderate or large institutions with equipment scanning over 300 different manufacturers, but which could be supplied by 20 or less. Thus, the necessity to deal with the smallest number of manufacturers possible needs to be re-examined. As you deliberate on this important theme, you need to ask yourselves the causes of this state of affairs within the continent, while at the same time bearing in mind that any factor affecting scientific instrumentation requires your concerted effort to find appropriate solutions.

In some instances, the users of equipment have absolutely no input into the selection of the type of equipment they need. Many times, equipment arrives with no operation manuals; sometimes spare parts are either not available locally or the equipment itself has to be sent back to the manufacturer for servicing. Such practices are too costly for Africa to service.

The continent has continued to be marginalised not only on the political and economic fronts, but also technologically. Africa must therefore, with urgency, build her own indigenous technological capacity to solve her problems in a sustainable way. This is in harmony with our other aspirations. We cannot forever continue looking to the developed world to solve our problems.

A survey of most equipment in African countries reveals a glaringly low level of technical complexity. All of you gathered here have the intellectual ability, within the various technical fields, to start designing and developing equipment of high and relevant technology for our continent. This will save both foreign exchange and the time involved in waiting for spare parts and service personnel from outside.

Let me emphasise the commitment that our country, and my Ministry in particular, has to the development and exploitation of available technical manpower and industrial capacity as a base for sustainable national development. This commitment ranks as a top government policy, as evidenced by the recent release of KSh 400 million (US$ 13 million) to assist among others, the establishment and enhancement of small-scale manufacturing projects. The Kenya Government has long realised that the development of Africa must be initiated and managed by her nationals themselves. Individually, this may be difficult but together, and in the spirit of unity, we can achieve our goals. Quality manpower and technologies developed at national and international institutions remain critical factors in sustaining technological development in Africa. Without an adequate and appropriate supply of each of these, our continent has no future.

You, as high-level representatives of Africa's technical and scientific communities, the industrial sector, and funding agencies, have the responsibility to provide guidelines on actions necessary to ensure that technical training and technological developments that are relevant to Africa's sustained economic growth are secured. You must take that responsibility most seriously.

Allow me to make two observations on the issue of technical training and technological development. First, in Africa the need for technical training and technological development is not a new philosophy; it has been discussed at various national and international fora. Indeed, most countries have taken steps to establish and implement strategies aimed at enhancing their technological base. A meaningful discussion on this theme must therefore be sensitive to achievements and experiences gained so far. This should form the basis for the development of new strategies.

Secondly, we should learn from the experiences of some developed countries which have applied technical training and technological development in their economic growth. Experience has shown that certain basic elements are essential to the development of a successful technology-based economy and these include the following:

- the political machinery that should institute supportive policies and create a conducive environment that is sensitive to technological advancement and facilitate increased production;

- a commitment to the development of a human resource base that can innovate and manage technology;

- appropriate designing of strategies for a technological focus based on the users; the objectives and implementation processes should be designed based on the needs of the users;

- sustainable sources of financing the high costs and risks associated with the development of suitable technologies.

As you discuss this theme of technical training and technological development, the above considerations should be examined in the context of Africa's economic situation and the cultures of her people. However, I am pleased to note that the Workshop will cover discussions on such topics as

(i) procurement of scientific instruments and equipment;
(ii) repair, servicing and maintenance of scientific instruments and equipment;
(iii) design and development of scientific equipment;
(iv) establishment and networking on instrumentation centres.

In discussing the above, the Workshop should attempt to review the processes by which policy makers, entrepreneurs and engineers can work together for sustainable techno-economic development in Africa.

The task before you in the next four days is very challenging. You have gathered here charged with the responsibility of preparing tangible and concrete recommendations for the development of the African continent. The future of technological development of Africa therefore lies in your hands. You should view this as a delicate but honourable responsibility. In addition, the recommendations you pass at this Workshop will guide policy decisions made in our continent in order to improve the living standards of millions of African people. You must therefore represent their interests effectively.

With this in mind, I believe you will apply your vast professional skills and experiences to

- carefully reviewing the present state of technical training and technology development in shaping the economic advancement of the continent;
- identifying any bottlenecks to the development of a technological culture among Africans;
- formulating a flexible plan of action with adaptable recommendations acceptable in African countries.

In your analyses, you should pay special attention to the possible problems that may be created by technology and its application in the African setting. It is my sincere hope that this Workshop will spell out specific roles and contributions expected from principal participants in technology generation and utilisation, i.e., the policy makers, industrialists, engineers and ultimately the consumers.

Distinguished Delegates, Ladies and Gentlemen, in conclusion, I wish all of you success as you deliberate over this important theme which is geared towards making a new Africa. I now take the opportunity to declare the Planning Workshop on Advanced Technical Training in the Repair, Servicing and Maintenance of Scientific Instruments and Equipment in Africa officially open.

INAUGURAL SESSION

WELCOMING REMARKS

T. R. Odhiambo

Director, The International Centre of Insect Physiology and Ecology (ICIPE) Nairobi, Kenya

A key element in the infrastructure for Science and Technology (S&T), and indeed for any serious work in scientific research and technology development (R&D), is the relevant equipment and scientific instruments to expand the observational range and heuristic possibilities of our primary sensory recorders in the eye, the ear, and the nose. Towards the outer limits of our sensory systems — such as observations on galactic phenomena taking place several millions of light years away, or the study of biological behaviour at the molecular or sub-molecular level, or the investigation of chemical events under very high atmospheric pressure — only research equipment purposely designed to observe and record such phenomena can provide the necessary information to assist us in building up an information superstructure to bring about a better human understanding of these events. Practitioners and students of science who cannot have direct and continuous access to such instrumentation are therefore in a disabled position to pursue these kinds of scientific endeavours.

We, in Africa, find ourselves in this instrumentally disabled position more often than not. Indeed, the refrain regarding the lack of relevant equipment for research, higher learning, and the application of technology to social services (such as health care, road building and maintenance, the servicing of manufacturing factories, and the maintenance of airports and harbours) is so constant and widespread throughout the continent that it has ceased to register with policy makers any longer. Nonetheless, the problem has now reached crisis proportions, as a Symposium on Scientific Institution Building in Africa recently stated:

> "In Africa in the last two to three decades, [the S&T] infrastructure is almost entirely absent, and its absence builds functional incoherence into the system. The S&T system floats in thin air. The gap reflects the gap in policy concerns by governments. Economic policy is focused on the bottom stratum, and nothing contributes to the infrastructure. S&T

policy bodies on the other hand focus on the top two strata. This analysis does not lead easily to prescriptions, but poses challenges for donor agencies and foundations." (ICIPE, 1991)

The challenge being brought to the surface is not simply directed to the donor community and the governmental supporting system; it is being directed as well to the institutions themselves, the African scientific community, and the engineering fraternity. All are being invited to bring about a complete sea-change in the management culture of our equipment and instruments for higher learning, R&D, and social services — towards technical and engineering efficiency, cost-effectiveness, equipment longevity, and accountability.

The laboratories for R&D and higher learning, and those for clinical analyses and investigations, as well as workshops for engineering works and construction, are littered with unopened crates of inappropriate, unusable equipment; floors are jammed with inoperational, broken-down equipment; stores are filled with degutted instruments; shelves are bereft of spare parts. For the initiated, these are profoundly eloquent market signals, which pinpoint the urgent need for technical and engineering services that are currently not being provided in Africa by the engineering fraternity. The sales engineers that we see so much of in Africa these days are merely salesmen; the workshop engineers are more interested in planning and coordination, while the S&T policy-makers have simply turned the instrumental crisis into a lament.

What is desperately required today in Africa is to construct a new culture for the repair and servicing of scientific equipment, and for the maintenance and reconstruction of every important item of such equipment. The goal is to have any vital instrument perform as effectively as its own specification limits determine, for it to have a long functional life, and for it to be a true friend of the scientist, the educationist, and the practitioner.

In order to reach this level of performance, the scientific user and the engineer or technologist in charge of instrument maintenance need to jointly agree on the type and make of the instrument to be acquired for the job at hand. It also requires that the base-line performance of the instrument must be set at the very time it is being installed for use. These two steps together establish the capacity level of the instrument, which then gives some proper basis for its subsequent maintenance, servicing, and operation.

This week's pioneering **Planning Workshop on Advanced Training in the Repair, Servicing, and Maintenance of Scientific Instruments and Equipment in Africa** is essentially meant to develop a road-map for constructing this new instrument culture in Africa. In this respect, we agree with Berger (1988) in the essence of road-map making when talking about the social scientist; but we believe that equipment engineers must go well beyond mere map-making:

> "The social scientist is a maker of maps. if you want to travel from point X to point Y, a map will be useful to you. It can tell you a lot about the territory you must traverse. But it can tell you nothing about the purpose of your journey, or whether you should undertake it in the first place. And the map will be useful to you only if it can be equally useful to someone who undertakes the journey for very different, possibly antagonistic purposes. The mapmaker has no qualifications to advise you about the moral status of your intended journey."

It is important that, once this Planning Workshop has provided landmarks for the new road we should follow in constructing the new equipment culture, the engineering and technological leadership must commit itself to realising this profoundly important goal.

References

Berger, P.L. (1988). Moral judgement and political action. *Dialogue* 84(2), 2–7.

ICIPE (The International Centre Of Insect Physiology And Ecology) (1991). *The New Challenge of Science and Technology for Development in Africa: Proceedings of a Symposium on Scientific Institution Building in Africa,* held at the Rockefeller Foundation Conference Center, Bellagio, Italy, 14–18 March 1988. ICIPE Science Press, Nairobi.

KEYNOTE ADDRESS: UNCONVENTIONAL APPROACHES TO DEVELOPING A MAINTENANCE CULTURE

A. Abdinaser

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I have the honour and privilege to convey to you the greetings and the welcome of the Director-General of UNESCO, Mr. Federico Mayor, during this important Workshop which is very timely for Africa and for its economy, with regard to the maintenance of scientific instruments and equipment.

The acute shortage of well-trained technical manpower in Africa, particularly for the maintenance and repair of scientific instruments and equipment, has been of great concern to UNESCO. At the Nineteenth Session of the General Conference of UNESCO (1976), Member States by Resolution 2140–42 authorised the Director-General to plan future programmes to search for ways and means to redress this regional problem.

During the inter-secretariat consultations that took place just after the CASTAFRICA I Conference (1974) between the OAU, ECA and UNESCO, it was decided that UNIDO be approached to take part in potential programmes along the lines of CASTAFRICA I recommendation No. 15, para(ii), which states that "UNESCO in collaboration with other competent organisations, assist the African countries in setting up their own plant for the production and maintenance of scientific equipment".

Background and Justification

Many African countries have for some time acquired costly scientific equipment, only to find that these soon break down and become inoperative because of lack of facilities and skilled manpower to maintain and repair them. Such problems have been faced by academic, scientific, technological and industrial institutions, including schools, as well as hospitals, transport and communications facilities, and different organisations in the whole region. The need for finding solutions to this regional problem has long been identified and most governments are aware of this need.

For the African Region, UNESCO has organised many regional workshops and meetings for training technicians in the maintenance and repair of scientific instruments and equipment since 1979. At all of these meetings and workshops, among other observations and conclusions on strategies to be adopted, it was felt that *no mechanism existed for coordinating action or exchanging information among the institutions which are involved in training such technicians.* A need therefore arises for the establishment of a network to disseminate such information and coordinate remedial actions needed for overcoming problems in this field.

Network of Instrumentation Centres in Africa

Conscious of the enormous financial resources expended on scientific and technological instruments and equipment, and taking note of the inadequate technical manpower and facilities in each of the African countries required to maintain and repair such equipment, it was decided at the Consultative Meeting organised by UNESCO in June 1989, that the long- and short-term objectives of the Network should be as follows:

LONG-TERM OBJECTIVES

- Raising the awareness of African governments, and scientific and technological institutions regarding the need to take appropriate measures in redressing the problem within the framework of improving the scientific and technological infrastructure for indigenous development.

- Serving as a cooperative forum for activities needed to develop the necessary instrumentational skills and strategies for tackling the regional problems in repair, maintenance and development of scientific instruments.

- Encouraging cooperative use and sharing of facilities, endorsing complimentarity and spreading expertise and facilities in the whole African region starting with the use of existing identifiable capacities in the sub-region.

- Engaging in instrumentation activities at all levels including the following areas:

  - routine maintenance and repair of instruments
  - major repair and calibration of instruments
  - training of all types of instrument personnel
  - innovation, fabrication, and adaptation of components as well as upgrading relevant indigenous technologies in the region

- Arranging assistance for each participating country to develop facilities needed to solve immediate urgent and looming local instrument repair and maintenance problems.

- Coordinating training of personnel covering the whole spectrum of instrumentation competence. In particular, it should emphasise the provision of on-the-job training to graduates of universities and polytechnics to be able to actually repair and operate instruments.

- Encouraging and assisting participating countries to compile inventories of scientific instruments on a national basis. It should also be in a position to advise, as and where necessary, on standardisation of the type and choice of scientific instruments and equipment so that repair facilities such as spare parts pools can be easily arranged and coordinated.

SHORT-TERM OBJECTIVES

It will be the function of the Network to:

- Promote the establishment of national instrumentation committees and eventually centres, where necessary.

- Facilitate information exchange on instrumentation matters throughout the region.

- Organise training workshops and seminars for relevant technical personnel.

- Cooperate with all regional and international bodies engaged in the field of instrumentation and interested in the affairs of the Network.

- Bring home the importance of this regional problem of instrumentation to African governments, the ECA, OAU and sub-regional economic organisations like ECDWAS, SADCC, UDEAC, etc., and solicit funds for setting up the Network.

Training for Maintenance of Scientific Equipment at Universities

Maintenance of scientific and technical equipment appears to enjoy very low priority in the scheme of things at African universities. The problem has already been addressed at many fora, but concrete action to raise awareness and introduce a maintenance culture has mostly been neglected.

Following discussions of the problem at the International Conference on "Promotion of Research-Oriented Education and Training at African Universities" organised in September 1985 in Nairobi, Kenya, the GTZ (Deutsche Gesellschaft für Technische Zusammenarbeit — German Agency for Technical Cooperation) commissioned an expert study into "Training for Maintenance and Service of Scientific and Technical Equipment at Universities and Scientific Institutions". The *study revealed a number of weaknesses and showed that lack of proper equipment maintenance was impeding significant progress in several essential university activities.* To help increase awareness and skills for equipment maintenance, it proposed a series of training workshops for three categories of personnel, namely:

Group 1: Users of Equipment (laboratory technicians, teachers, researchers and students).

Group 2: Maintenance and Repair Personnel (repair technicians and engineers).

Group 3: Organisers and Administrators (heads of laboratories, workshops, and departments, deans, finance office staff).

Following acceptance of the report, it was decided that the workshop series should be jointly organised by the UNESCO's established African Network of Scientific and Technological Institutions (ANSTI) and GTZ. Workshops for Group 1 are to be organised.

Finally, to the extent that the magnitude of instrumentation problems can best be brought home to governments through the compilation of directories of scientific instruments, including the total cost of investment in scientific instruments and equipment, UNESCO will encourage and assist participating countries to prepare such surveys and provide consultants and advisors where necessary. UNESCO will collaborate with other regional and international organisations interested in this important task.

Preventive Maintenance

The axiom "Prevention is better than cure" equally applies to scientific instruments. One might rightfully ask: Why does a maintenance programme fail in a developing country? The maintenance problem is also a behavioural problem and might be the fundamental reason why the various technical schemes, looking at technical solutions alone failed to introduce a "maintenance culture". Central repair workshops have been established, without taking into consideration the logistics of sending equipment to and from the workshop. Low salaries make technicians leave after their training for greener pastures or for better pay in the private sector. *Improved maintenance can come from a change of behaviour in the workplace, and the change must be present throughout the entire organisation to succeed. Usually this does not happen, unfortunately.*

DEVELOPMENT OF A MAINTENANCE CULTURE

Could we achieve a better result using unconventional means? How could we develop the behaviour of a "maintenance culture" in the workplace, and in schools, and in institutions considering that "prevention is better care of the equipment? If "prevention is better than cure", could we move from the existing "Breakdown Maintenance" practice to a "Preventive Maintenance" practice, and if yes, how do we effectively implement such a scheme? Hereunder are some examples of unconventional proposals which could be discussed at this Workshop.

During the spring of 1990 a *UNESCO/UNDP-sponsored mission in five Asian countries, showed that the maintenance problem starts long before the equipment arrives in the country, at the specification and ordering stage.* From the specification to delivery, a piece of equipment passes through a long chain of people who have a "say" in it. As everyone looks at it from a different point of view (technology, cost, prestige, etc.), it is no wonder that a future maintenance problem could be created simply by choosing the wrong model of an item (e.g., when the model has no local repair facilities). A donor could also create a problem by supplying equipment without a maintenance package such as inclusion of the essential drawings and training manuals. Being a "donation", it is unlikely that the recipient will object, but he will find himself in trouble when the first fuse blows.

SEMINARS ON MAINTENANCE AWARENESS

An unconventional solution could be a **Maintenance Awareness Programme**, to make the people who select, approve, or supply equipment, become aware of the problems related to the maintenance and decide accordingly. This seems an impossible task; however, a series of local seminars to discuss the maintenance problems related to new equipment could stop the importation of "white elephants" into the country. The participants to such a seminar should be the people connected with the equipment: donors, project managers, embassy personnel, officers of international organisations, as well as local officials from ministries and foreign and recipient institutions.

Looking at the preventive maintenance, we may say that the problem starts long before the worker reaches the machine tool, at the vocational school level. The UNESCO/UNDP mission quoted above, showed that *in a great percentage of schools, equipment is unusable for lack of maintenance. Today it is most likely that the student will take with him, in his future job, the negative attitude towards the maintenance of equipment he acquired in the school.* An unconventional approach could be the introduction of a **Preventive Maintenance Programme** at the school level, even at primary school level. The objective: to maintain the school equipment — any equipment. Such a programme could change the behaviour of the student for the benefit of the school and his future employer.

The operation of some general-use machinery (e.g., photocopiers) is sometimes presented as a set of dull written instructions like : remove cover, place paper, switch on.... Nobody "reads" such instructions and the result is very often mishandling of the equipment. An ergonomics approach in the presentation of the same information could make a big difference. This could be a step-by-step utilisation of a drawing and/or a trouble-shooting chart, placed near the machine and clearly marked. An unconventional approach to the maintenance of this type of equipment could be a **programme in each factory or school, to first identify which machinery or equipment is abused** by the users because of lack of appropriate instructions, and placement of ergonomics instructions near each machine or apparatus prone to be damaged by incorrect manipulation.

The proposed seminar will convene a group of experts from the developed and the developing worlds who will look at the maintenance problem from their own experiences as recipients or project managers. They should present papers on unconventional solutions such as the ones mentioned above, or on any methodological approach such as : Quality Circles (QC), Action Learning (AL), Interfirm Comparison and Business Clinics (IFC/BC), applied to the maintenance problem.

Can an unconventional maintenance programme have a better chance of success where other programmes have failed? *Even if this seminar would generate only a partial solution to the maintenance problem, millions of dollars of equipment could be saved.*

MANUAL FOR PREVENTIVE MAINTENANCE

In August 1990, UNESCO fielded a consultant on a mission to some selected higher level technician-training institutions in Africa with the aim of gathering information on the most widely utilised scientific and technological instruments and equipment in those institutions and associated industries. As an outcome of this survey, a "Manual for Preventive Maintenance of Scientific and Technical Instruments and Equipment in Technical Institutions" has been published by UNESCO. The Manual (both in English and French) will be distributed to the participants of this Workshop.

Finally, here is our best wishes for the success of the Workshop.

KEYNOTE ADDRESS: EQUIPMENT AND TRAINING REQUIREMENTS FOR RESEARCH INSTITUTES IN AFRICA

G. Nderitu

Director, Kenya Agricultural Research Institute (KARI)
Nairobi, Kenya

(Read by Dr. A.M. Kilewe, Centre Director,
Soil and Water Management, KARI)

The KARI Equipment Maintenance Unit

KARI has a wide variety of scientific equipment scattered in various centres within the Republic. The equipment originates from many of the developed countries either as donations or procured through foreign loans. The donor agency in most cases decides on the origin of the equipment. The manufacturing firms from whom the equipment is bought often have no local agents or representation; hence, maintenance becomes a problem. It is after this experience that KARI set up an Equipment Maintenance Unit at Kabete to service all its centres countrywide.

Scientific instruments and equipment range from the simplest ones such as the room heater to the more advanced ones such as the Atomic Absorption Spectrophotometer (AAS), the Gas-Liquid Chromatograph (GLC) and the Autoanalyser. This wide variety employs diversified technological fields and even more than one field of study may be employed in one instrument. The major study areas employed in the design and manufacture of scientific instruments and equipment are: electronics, electrical engineering, and mechanical engineering. The repair technician needs to have a basic background in these areas for effective expertise in repair and maintenance. It is a common fact that scientific equipment is expensive, and buying a new piece of equipment whenever the existing one fails is not always possible. Although a situation may demand a new machine, it is much more economical to try as much as possible to maintain and repair the already-existing equipment. This prolongs the lifetime of the equipment and thus saves on scarce foreign exchange expenditure.

Problems and Training Needs Experienced by the Maintenance Unit

ACQUISITION OF SPARE PARTS

Though many common spare parts are locally available, a few are extremely difficult to get and at times ordering through other agents takes quite some time. The wide variety of scientific instruments and equipment makes even the preparation of a list of spares to be stocked a difficult task. Acquisition of these spare parts is a major problem due to the absence of local representatives of equipment-manufacturing firms. Expatriates undertaking certain projects within KARI have helped the Unit in acquiring some of the spares that are difficult to obtain.

INVENTORY AND CATEGORISATION

Scientific equipment can be subdivided into various categories depending on their specific applications or make. On application, the equipment could be grouped as shown below, just for example:

Weighing equipment
Analytical equipment
Animal science research equipment
Sample preparation equipment
Medical equipment

On manufacture, the equipment could be grouped as either mechanical, electrical or electronic, or a combination of any of the three fields. Inventory and Categorisation during repair and maintenance helps in selection of the test equipment and tools required for the repair work and of the spares to be stocked. It also helps in determination of the types of training to be offered to the maintenance personnel. In many institutions, and in Kenya in particular, Inventory and Categorisation is lacking, and hence poor equipment repair and maintenance results. Training on the importance of Inventory and Categorisation is vital.

MANUALS AND DRAWINGS

In repair and maintenance, manuals and drawings are essential components. They assist in fault diagnosis and where spare parts are lacking, they help in improvising the equipment. Much of the equipment in our local government institutions come as donations, and many come without service manuals; for example, in KARI there is some equipment which has gone faulty and due to lack of circuit diagrams, has not been repaired for a long time. Examples of these are the Pye Unicam SP30 UV spectrophotometers, SP9-10 Pye Unicam AAS gas control units, Sartorius electronic balances, Pye Unicam PM 8251 pen recorders, and the AR55 Pye Unicam linear recorder. Others include Conviron incubators from Canada.

DATA AND REFERENCE BOOKS

Data and reference books are equally important. These help in selection of the equivalents or alternative of electronic spares where the original ones are not available. Instrument journals and magazines update the technician on changes in technology and also serve as teaching aids to trainee technicians. Data and reference books are, however, expensive and not easily available to most technicians. Journals and magazines reach the technician late, if at all. A training institution with a good library would make a good resource centre.

CORRECTIVE AND PREVENTIVE MAINTENANCE

The working life of equipment is prolonged if proper maintenance is carried out. *Corrective maintenance which involves reviving an inoperative instrument takes a lot of time, due to the generalised training offered in many local institutions. A training institution on Specialised Scientific Equipment would alleviate this problem*. Training on this specialised equipment will vary from one institution to another, depending on the types of equipment they have. KARI technicians, for example, require service training in some of the more advanced equipment like X-ray refractometers and the ultracentrifuge which are refrigerated and electronically controlled, as well as the Gas Liquid Chromatograph (GLC), the Atomic Absorption Spectrophotometer (AAS), and the Autoanalyser, which are microprocessor-based. A thorough knowledge of an equipment and its operation would help establish the preventive maintenance required to guarantee continued operation. This calls for operational training and experience in order to identify the parts that require preventive maintenance and how often to carry it out.

CALIBRATION

Calibration is an important aspect once an equipment has been serviced, if correct results are to be expected. This will ensure that valuable time and resources are not wasted. At present here in Kenya, the most easily available calibration service is on weights and measures provided by the Weights and Measures Department of the Kenya Bureau of Standards. Calibration service on many other types of scientific equipment is lacking due to lack of standards and know-how. Training is highly required in this field. The proposed Centre should consider incorporating a Calibration Section for scientific equipment.

LOG BOOKS

To ensure quick maintenance of a specific equipment, the keeping of a log book is very useful. These will assist in knowing the common and persistent problems with the machine, the spares to stock and any necessary modifications to carry out. Training on log-book keeping on scientific equipment is needed.

SPARE PARTS

Knowledge about spare parts and their acquisition are important aspects if the mean time to repair an instrument is to be minimised. This comes about with experience and knowledge of supplies. Most companies which sell scientific equipment to African countries only have sales representatives in these countries, and many of these representatives have little or no knowledge about the spares of the equipment they sell. The few companies who stock the spares will not sell them unless they are given the repair job for which they charge exorbitantly. Here in Kenya, certain spares are not so easily obtainable. A lot of time is wasted in waiting for the spares to arrive from abroad, and thus the repair time is lengthened.

MANPOWER

The courses offered in many African institutions are general and hence qualified manpower on scientific equipment maintenance is lacking. Due to poor renumeration for technicians jobs in Kenya, many people opt for other better-paying careers. The few technicians available are inexperienced and unable to cope with changing technologies. There are no refresher courses for these technicians and hence no updating of their knowledge. A Training Centre where refresher courses are offered will be an asset.

PHYSICAL FACILITIES

Most institutions have poorly-equipped workshops or none at all, due to lack of expertise and finances. Knowledge of the tools and test equipment to equip a maintenance workshop is lacking, and where this is available, the cost of test gear and tools is high for developing countries. This results in poor equipment fault diagnosis and hence improper repair if at all. Thus, much equipment goes to waste and lies idle.

USER/SERVICE PERSONNEL INTERACTION

Due to financial constraints in developing countries, workshops and seminars where user/service personnel interaction could be established is lacking. This interaction, if created, could lessen the maintenance problems caused by operational errors.

Establishment of an Instrumentation Centre

In Africa today, and more especially in Kenya, the existing training institutions offer generalised engineering courses but none on scientific equipment maintenance and repair. There is therefore an urgent need for Africa to set up an Instrumentation Centre for training its manpower and which would be used as a Resource Centre equipped with a well-managed library offering the latest instrument journals, magazines, data and reference books.

ESTABLISHMENT

Establishing an Instrumentation Centre would require substantial amounts of money. Since African countries are restrained by resources, setting up such a Centre would mean a lot of sacrifice and dependance on aid from well-wishers to meet the following costs:

- construction and setting up buildings
- capital costs of equipping the Centre
- training highly skilled personnel to run the Centre
- running and maintaining the Centre

COURSES

Courses offered in African training institutions, taking Kenya as an example, include electronics engineering, electrical and mechanical engineering, instrumentation, refrigeration and air-conditioning, and of late, medical engineering. The technologies used in the designing of modern scientific equipment intermarry the above areas of study.

It is therefore necessary for a scientific equipment maintenance technician to have at least a basic knowledge of the first four fields of engineering study, not forgetting computer applications, and the design and development of scientific equipment. The proposed Instrumentation Centre should strive to achieve this by setting up a suitable syllabus and where possible, arrange industrial attachment of trainees in reputable equipment manufacturing firms.

It is also necessary for the Centre to be able to offer special training on some specific specialised scientific equipment, depending on the complexity and the user institution's requirements. KARI technicians, for example, would require training on the following equipment:

Atomic absorption spectrophotometer (AAS)
Gas-liquid chromatograph (GLC)
Ultraviolet spectrophotometer (UV)
X-ray refractometer
Automatic adiabatic bomb calorimeter (Autobomb)
Near infrared analyser (NIR analyser)
Leaf area meter
Ultracentrifuge

WORKSHOPS AND SEMINARS

This Instrumentation Centre should offer facilities for workshops and seminars for maintenance technicians, engineers, laboratory managers, laboratory technologists and equipment operators. This will enable people from various countries and institutions to interact and exchange ideas.

EXHIBITIONS AND DISPLAYS

The Centre should be made available for equipment manufacturers and designers to exhibit and display products, thus bringing about an awareness of new products or those that are unknown to them. This facility should be open for educational and research organisations to display what they have and what they do. This will help in bringing awareness to each other of what is locally available and will enable organisations to borrow or hire equipment from one another to save on the resources.

PHYSICAL FACILITIES

A major requirement of the Instrumentation Centre is for it to have physical facilities such as a library, electrical and electronics laboratories, a mechanical workshop, a design and development centre, including drawing offices, and hostels and recreational facilities. Training facilities should include electrical and electronics test gear, refrigeration service equipment, computers for design and development, etc.

HUMAN RESOURCES

The trainers should be highly qualified personnel in the various fields of engineering, design and development, computer and laboratory management. Lectures by people from reputable equipment manufacturing firms and experienced laboratory managers would serve as a useful part of the training.

EQUIPMENT HIRING AND RENTAL

Some research and educational institutions require from time-to-time servicing of some specialised equipment which they cannot afford or which they use once in a while and which would be uneconomical to own. The Training Centre should identify such equipment, acquire and offer them for hire and rental.

EQUIPMENT REGISTRY, TECHNICAL ADVICE AND TECHNICAL DOCUMENTATION

An Equipment Registry within the Centre with a record of the available equipment in Africa and their performance as experienced by the user will serve to advise buyers on the most reliable equipment. The registry should have a record of the various scientific equipment, suppliers, what they offer, latest developments and be able to offer technical advice to needy institutions.

LABORATORY MANAGEMENT

The Instrumentation Centre should also offer courses on laboratory management to all cadres of research personnel. This will ensure better and longer use of laboratory equipment.

Ensuring Procurement of High-Quality Scientific Equipment

In a scientific organisation, the need and therefore the demand for equipment is tailored to the scientific activities undertaken within the organisation. The equipment required are sometimes replacements for either old unserviceable or obsolete equipment. However, as technology advances there may arise a need for replacing equipment with more efficient and precise equipment.

In order to procure equipment that will be effective and useful, the following measures should be carried out:

- The user must know the objective equipment, i.e., what sort of analysis is required.

- The user must work out a specification for the equipment required with reference to the objective (i.e., results, precision and their variances) without necessarily copying old technical literature which might not help to specify the user's requirements. In most cases, technical literature is prepared by manufacturers whose specifications are standard, i.e., they have specific variances and therefore static precision.

- In order to safeguard the Third World from unscrupulous merchants and manufacturers, it is important to first and foremost devise ways and means of ensuring the equipment procured is new and recent, if not the most immediate model series from the manufacturer. This safety device can only be applied when the government of the country of origin takes full responsibility for censuring the sales of obsolete equipment to other countries. In fact, they should issue certificates, instead of delegating such responsibilities to profit-making organisations that are only profit-orientated and at times do not care or will not bear responsibility for poor or sub-standard quality equipment.

  More often than not, scientific equipment procured for the Third World/Africa are in an earlier model series likely to have no spare parts for repair and maintenance. In some cases equipment has been bought in Africa purportedly new, whereas in the country of manufacture, that very model went out of production a few years back. More seriously, some equipment has made its way into Africa after it has been reconditioned, but sold or marketed as being new. This does not only give less value to the equipment, but its efficiency and precision would definitely be poorer.

- The buyers — countries of destination — in almost all cases, should try to carry out inspection prior to shipment of the equipment. If this were done, it would discourage dishonest businessmen from selling poor-quality equipment to the Third World.

- Another measure that would be useful to ensure that good quality equipment is sold to the Third World would be to obtain such equipment from established manufactures, who I am sure would show concern about selling their products and would even follow-up such equipment by either appointing capable representatives in areas where they have sold their equipment, or will have ensured that backup services are provided by them on a regional basis and will have made provision that spare parts be availed.

Recommendations

To summarise, the following can be recommended:

- Supply Market Research for scientific equipment must be carried out by both procurement officers and technically qualified officers.
- Specifications for scientific equipment should always be based on the desired analytical results rather than extracting such specifications from the existing manufacturers' literature.
- Inspection of the scientific equipment should be carried out on the production line to ensure that the quality specified is adhered to. This inspection should be carried out by the country of origin and a certificate issued to the user/purchaser.
- The tender dossiers should be designed so as to enable the manufacturer to tender and such manufacturers should appoint effective agents to facilitate after-sales servicing.

KEYNOTE ADDRESS: ESTABLISHMENT OF A MAINTENANCE PROGRAMME IN BRAZIL

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First of all I would like to thank our hosts for the invitation to visit this beautiful city of Nairobi, of which I have heard so much from films and TV reports, but had never had an opportunity to visit. I come from a large country, Brazil, in South America, a country of about 8 million square kilometers in area, and 150 million population, and extending from a little to the north of the Equator to about 33° latitude south. The mouth of the Amazon River is about the latitude of Nairobi. The city of Sao Paulo sits practically on the Tropic of Capricorn, which passes a little to the north of Johannesburg and Pretoria, in South Africa.

The city of Sao Paulo, where I live, is a huge megalopolis of over 14 million people, and growing — with all the problems that such size and growth entails. Water requirements are enormous, and the cost of implementing it are very large. Waste water treatment, which is perpetually growing, consumes another huge amount of money. Garbage disposal is another big problem. Dumping sites are being rapidly filled and research on other forms of disposal, such as incineration and recycling, are going on at a furious rate. We are running the risk of being buried by our own refuse.

Being a large country, of continental size, Brazil has a number of universities and institutes throughout its territories, many of them belonging to the federal government or to the state governments. Periodically, research and development programmes are being sponsored, some by the federal government and less frequently by the state governments. Right now we have a programme going on called the National Program for Scientific and Technological Development, sponsored in equal parts by the World Bank and the Federal Government. A number of technical areas have been supported by this programme such as instrumentation, agricultural projects, medical research, and many others.

One of the sub-programmes covered by the overall plan is the Maintenance Sub-Program. Decided during the negotiations of the Federal Government with the World Bank some five years ago, this *Maintenance Sub-Program has as its principal merit the establishment of a consensus in the scientific community that institutions should be able to provide maintenance by their own means, at least at the basic level.* I am not talking of the usual buildings and grounds type of maintenance, which most institutions have, but maintenance support for the instruments and equipment used for research and teaching.

Up to the 1980s, problems related to maintenance of this type of equipment was relegated to a minor role in the affairs of most institutions. This was more a result of the cultural behaviour of researchers than to a real lack of funds, because when the situation became critical, these funds would somehow appear. The first change in attitude on the part of researchers started with a reduction of available funding for the purchase of new equipment (which would substitute for the damaged ones) and for payments to the external maintenance suppliers.

This Sub-Program has been going on for about three years, and some palpable results can be seen. At the same time as some quite successful Maintenance Centers have been implemented, it is believed that the biggest victory has been to profoundly change the cultural attitude of our researchers and institution managers as to the importance of equipment maintenance for the continuity of research activities.

Another area of consensus has been an understanding of maintenance activity in a broader sense, which includes the active participation of maintenance management in the selection processes for the acquisition of new equipment; the establishment of preventive maintenance programmes; and the training of laboratory technicians in the proper use of the equipment and in operational maintenance, that is, simple maintenance that can be successfully performed by operational technicians.

Finally, the technical community appears to have come to the conclusion that support for this kind of Maintenance Sub-Program must necessarily be of a transitory nature. In fact, once having changed the deprecative attitude of researchers and institute management towards the maintenance activity, they have understood that this activity should be institutionalised adequately with the necessary operational funds placed in the budget year-after-year. Eventual funds for expansion could be obtained through regular channels of financial support of research and development activities.

This means that, once the technical and institutional maintenance structure of the types planned in the Maintenance Sub-Program in Brazil are consolidated, new programmes of this type which are essentially an emergency action, will no longer be necessary. This also means that researchers and users of these Maintenance Centres, should provide in their project budgets, funds to repay the costs of requested services.

I have spoken about the broad ideas behind the Maintenance Sub-Program on-going in Brazil, but I have given no actual figures and actions, which I think will be of interest to you. There are five actions being supported within this Sub-Program, in its second phase:

- *Support for maintenance structures and the consolidation of existing structures.* The continuous evolution of teaching, research and development activities, requires that the maintenance structures that service the corresponding equipment also be capable of improving and widening their competence in servicing existing and new equipment. This will only be possible if such maintenance structures are properly placed in the overall structure of the institution, both operationally and financially.

- *Support of new maintenance activities in teaching and R&D.* This objective is to reach the programme goal of 87 maintenance units, 14 maintenance nuclei and 21 maintenance centres throughout Brazil.

- *Networking the existing maintenance structures.* A complementation of the activities of a given centre could be obtained by support given by another centre, transiently or permanently, once they are interconnected in a network.

- *Support of technical training.* Training of maintenance technicians is a permanent activity.

- *Support of maintenance of specific families of instruments.*

The idea that a Maintenance Center could provide services to all kinds of the great variety of instruments and equipment available in large research institutions is really a topic of interest. Therefore, the idea is for each Centre to specialise in maintenance of specific families of equipment, such as electron microscopes, mass spectrometers and the like. General-purpose instruments such as multimeters, oscilloscopes, and function generators could be serviced by any one of the Maintenance Centers.

The budget for this Maintenance Sub-Program, for a period of five years (for this second phase 1990–94) totals US$ 2.9 million with at least the same amount of local funds. As I said before, the foreign funds are provided by the World Bank, on a long-term loan.

I hope I have been able to give you an idea of the programme for the establishment of maintenance centres in Brazil. We have had in my institution in Sao Paulo one maintenance project which is almost finished, and we are just about to start a new one, a continuation of the first one, at the end of which we expect to have a fully functional Maintenance Center.

I wish to thank you all for your attention, and hope that we may continue to exchange information and views on this most crucial activity, which is the maintenance of equipment in teaching, research and development institutions. I also wish to thank the organisers for the opportunity of giving this talk, although I am not the typical Keynote Speaker, with his many jokes and tall stories. Thank you all.

SESSION I

PROCUREMENT OF SCIENTIFIC EQUIPMENT IN AFRICA

CHAIRMAN: P.O. Okaka

Director of Technical Training
Ministry of Technical Training and Applied Technology
Kenya

ROLE OF INSTRUMENTATION CENTRES IN PROCUREMENT OF SCIENTIFIC EQUIPMENT IN AFRICA

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Lack of scientific equipment in Africa is one of the most important factors which retards the growth in research and development programmes. This lack is due to the fact that most of this equipment is imported from developed countries, while administrative and financial procedures for their importation need a long time. This is due to the severe shortage in hard currency in developing countries. At the same time, the political and economic relations between importing and exporting countries have a great effect in accelerating or decelerating these procedures.

In addition to the problems mentioned above, the imported equipment rapidly falls into disuse and wastage. This is due to the following:

Incorrect choice of the equipment
Improper use of the instruments
Shortage in maintenance of the equipment
Unavailability of spare parts

To overcome the problems of lack of scientific equipment which results from rapid wastage, the following points must be kept in mind. Advice of the experts and the consultants is of great importance in the proper choice of the equipment.

- The choice of the equipment must be according to the following considerations. It must
  - fulfill the required purpose
  - be of the required capacity
  - be as multi-purpose as possible

- be designed to be operated under environmental conditions, similar to that of the operation location, especially with respect to ambient air temperature, relative humidity and dust content
- be harmonious in its power supply conditions especially voltage and frequency, with that of the operation location.

- The user of the equipment must possess sufficient knowledge and the practical skill necessary to look after the equipment.

- Maintenance engineers and technicians must develop the appropriate skills to keep abreast of new technology advances.

- Spare parts of imported equipment must be ordered and supplied together with the equipment.

Establishing an Instrumentation Centre

Establishing an Instrumentation Centre is an effective way of achieving a suitable and long-term solution of the above-mentioned problems. This Centre might include three main divisions in addition to some supplementary departments. The main divisions are as follows:

Consultation division
Maintenance division
Training division

OBJECTIVES OF THE CONSULTATION DIVISION

- Consultation for proper choice of equipment.

- Collection of the updated information about the advanced equipment from the following points of view: knowledge about equipment suppliers; technical data of different equipment which includes the scientific principles and methods of operation and maintenance.

- Compilation of statistical information on the present equipment in different local institutions and the possibility of exchanging this equipment between different users according to their needs.

- Consultation about the manufacturing of some scientific instruments which can be locally made.

- Consultation about the development of some existing instruments to be used for different purposes or to be used at different ranges.

OBJECTIVES OF THE MAINTENANCE DIVISION

- Scheduling and executing the periodical protective maintenance of the working equipment in its place of operation.
- Repair of faulty equipment.
- Initial and periodical adjustment and calibration of the equipment.
- Design and construction of some devices which are required for adapting the operating conditions to fulfill the equipment requirements.
- Design and manufacturing of some special instruments to be used in special processes for use by local facilities.
- Design and manufacturing of some spare parts with the use of local materials.
- Design and manufacturing of instrumentation systems using local and imported components.
- Assistance in the technical investigation of the equipment received from the suppliers.
- Assistance in establishing small maintenance divisions in scientific institutions. These divisions help in the rapid and small maintenance work needed during equipment operation.
- Arranging for the spare parts requirements for the operation, maintenance and repair of the existing equipment in different scientific institutions and centres.

OBJECTIVES OF THE TRAINING DIVISION

Training of engineers and technicians on the following:

- Electrical and mechanical principles of scientific equipment.
- Choice of proper equipment.

- Effective use of different equipment.

- Protective periodical maintenance.

- Adjustment and calibration procedures.

- Repair and overhaul of scientific equipment.

- Adaptation of the operating conditions of the equipment to be equivalent to that recommended by the manufacturer.

SUPPLEMENTARY DEPARTMENTS

The Centre may include supplementary departments, such as a renting and exchanging department, in addition to a spare parts section. The Renting and Exchanging Division would have its own equipment which could be rented to some institutions for temporary use. Another activity of this department could be the purchasing of some used equipment from the authorities which don't need them. This equipment could be sold or rented to other users, provided it is in good condition, otherwise reconditioning must be conducted.

A Spare Parts Section would be of great importance in shortening the out-of-order periods of the equipment. Importing of spare parts needs a long time before the parts are actually in hand, due to the same afore-mentioned reasons.

Conclusions

From the above discussion, it can be concluded that establishing an Instrumentation Centre can play an important role in procurement of scientific equipment in Africa. The objectives of such a Centre are summarised below:

- Consultation on the proper choice of equipment.

- Advising about the most effective use for the equipment.

- Reduction of equipment wastage by means of protective maintenance and repair.

- Developing appropriate skills of engineers and technicians and constantly upgrading them to keep abreast of new technological advances.

ICIPE'S EXPERIENCE IN PROCUREMENT OF SCIENTIFIC EQUIPMENT

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Introduction

The International Centre of Insect Physiology and Ecology (ICIPE) was established in April 1970 as an institute for advanced research into insect science and its applications. The prime concerns of the ICIPE are:

- Research into integrated control methodologies for crop and livestock pests and other related anthropods, as well as insect vectors of tropical diseases crucial to rural health in the tropics (especially in Africa).

- Strengthening of scientific and technological capacities of developing countries in insect science and its applications through training and collaborative work.

The administrative structure of the ICIPE is shown in Figure 1.

A close view of the Workshop and Laboratory Services Unit (WLSU) is shown in Figure 2 . The unit has a staff establishment of approximately 40, with 22 of these based at Duduville in Nairobi, the rest being based at Mbita Point Field Station, 500 km away on the shores of Lake Victoria. Among the four sections within WLSU, the Instrumentation Section is responsible for all matters pertaining to instruments and equipment. The major responsibilities of the section are to

- repair, service and maintain all of ICIPE's laboratory instruments and office equipment;

- maintain an equipment inventory;

- provide technical advice and full participation in the purchase, installation and commissioning of all new instruments/equipment;

- co-ordinate maintenance service contracts with outside agents when the need arises;

- carry out design work for scientists on specific projects;

- co-ordinate and conduct relevant training to service and user personnel on instruments.

The main discussion of this paper will focus on the provision of technical advice and full participation in the purchase, installation and commissioning of all new instruments and equipment.

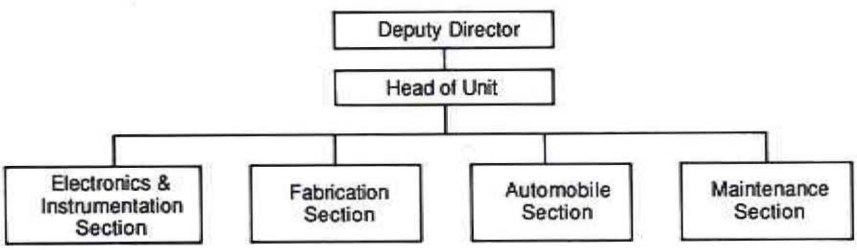

Figure 2. *Structure of Workshops and Laboratory Services Unit (WLSU)*

Procurement of Scientific Instruments and Equipment

ICIPE'S EQUIPMENT PROCUREMENT HISTORY

The ICIPE's funding was first based on individual scientists' soliciting for funds from various sources including the USA, Europe, Japan and Africa. This trend continued for a long time, approximately 10 years into ICIPE's existence, and included procurement of equipment under equipment grants. Several distinct patterns emerged during this period and can be summarised as follows:

- Relevant engineering consultations were not followed at the project preparation and planning stage. This means that due consideration was not given to the existence of relevant infrastructure, maintenance expertise, and suitable makes and types of equipment. Therefore, most individual scientists selected equipment based on their familiarity with them either during their academic careers or during attachment to other laboratories.

- Proper budgeting procedures did not take into account other costs apart from the original cost of the equipment, e.g., initial stocking and availability of spares, specialist training and availability of service and operation manuals. In fact, some donors insisted on supplying equipment only from manufacturers and countries of their choice.

- Due to lack of proper consultation and knowledge, as already stated, both the scientists and donors did not take into consideration equipment specification or environmental suitability.

- Proper installation and commissioning procedures were not followed.

These factors led to the acquisition of the wide variety of instruments and equipment currently available at the ICIPE and the associated maintenance problems we have here today. The latest statistics show that the ICIPE has an equipment establishment in the region of 3000 pieces, with 703 known manufacturers and 83 unknown manufacturers. Most of this equipment can easily be categorised into not more than six major functional groups. It is not difficult to imagine the problems WLSU has faced, with the first step being to repair and maintain this wide variety of instruments throughout.

NEAR-IDEAL PROCUREMENT PROCEDURE

In an ideal procurement situation, the following points must be taken into account:

- The type and range of equipment required must be taken into account at the project preparation and planning stage. The existing infrastructure and its ability to accommodate and maintain the equipment being procured must not be overlooked.

- Credible and reliable suppliers must be identified at an early stage and they in turn must also be able to understand the environmental conditions under which the user operates to enable them to make any necessary adjustments on the equipment prior to delivery.

- In many cases institutions only make budgetary provision for the initial cost of the equipment, ignoring such basic but important facts as availability of trained manpower for maintenance and operation, etc. In cases where special training is required, it must be included at the planning stage.

- Wrong or poor equipment specification schedules are a common problem almost everywhere. This has led to many institutions ending up with either what they do not want or equipment solving only half their requirements. It is important that all relevant personnel are involved in preparing the specification schedule and where expertise is not available, it is advisable to seek the assistance of consultants.

- Last, but not least, many instruments have been destroyed or their lifespan shortened because of installation by unqualified personnel. The recommendation is that qualified service personnel, together with the user, fully participate in the installation and commissioning of the equipment.

Present ICIPE Procurement Procedure

The ICIPE recognised the problems associated with haphazard acquisition of equipment and the problems that arose due to the wide variety and diversity of suppliers. It is with this in mind that a proposal was mooted to develop a standard equipment purchase requisition form to help reduce the problem. A sample of the form is shown in Appendix I. This form was designed based on ICIPE's experience over the years and is divided into three major sections, viz:

- *Section one (to be filled by the applicant or user).* The first step is the approval by the vote-holder to indicate that funds are available. The section then continues to seek such information as equipment name, make, model, preference of manufacturer (for which reasons should be given). The intended application and location of the equipment are also important considerations that should be supplied by the user.

- *Section two (to be filled by WLSU).* This is the most important section as it ensures that the best compromise is made based on the following factors:

  - sharing of equipment in the case where a similar one already exists and is not fully utilised;

  - suitability of the proposed manufacturer, taking into account the initial cost and projected maintenance problems;

- special services that may be required like steam, compressed air, special cooling facilities, UPS, stabilised power supply, etc.;
- complexity of the equipment and whether this may necessitate special service and operation training.

- *Section three (to be filled by the requesting Programme and Supplies Department).* The vote-holder makes his comments on WLSU's response and proceeds, if there is no further clarification needed, to forward the form to Supplies Department to make the necessary purchase order.

On receipt of the equipment, the installation and commissioning is carried out by WLSU staff, who on successful completion, hand over the equipment to the user.

While these items within the form may not be exhaustive, the ICIPE feels that it makes a good starting point for an orderly procurement system. Plans are already under way to streamline some of the problems faced so far, the major ones of which are:

- Some scientists, especially those on specific projects supported from their home countries, still bring in equipment without following these procedures.

- There is sometimes an initial mistrust between scientists and technical personnel. The scientists have felt that the technical personnel are interfering in their traditional domain and have been reluctant to accept the new method. However, this is being solved now after a spirit of co-operation rather than confrontation.

- The ICIPE Supplies Department for some time continued to order equipment without consultation with WLSU. This has now reduced and WLSU enjoys maximum co-operation in this area with the Supplies Department.

Summary

The paper has described the major problems that have faced ICIPE in the field of equipment procurement since its inception. The attempt to address these problems and find solutions to them have been described in detail. Experience has shown that the involvement of engineering staff in the procurement procedure right from the planning stage is crucial to the future maintenance of the equipment. One area that is difficult to control is the situation of equipment grants where strings are almost always attached, even though with dialogue, it is a problem that is still possible to overcome.

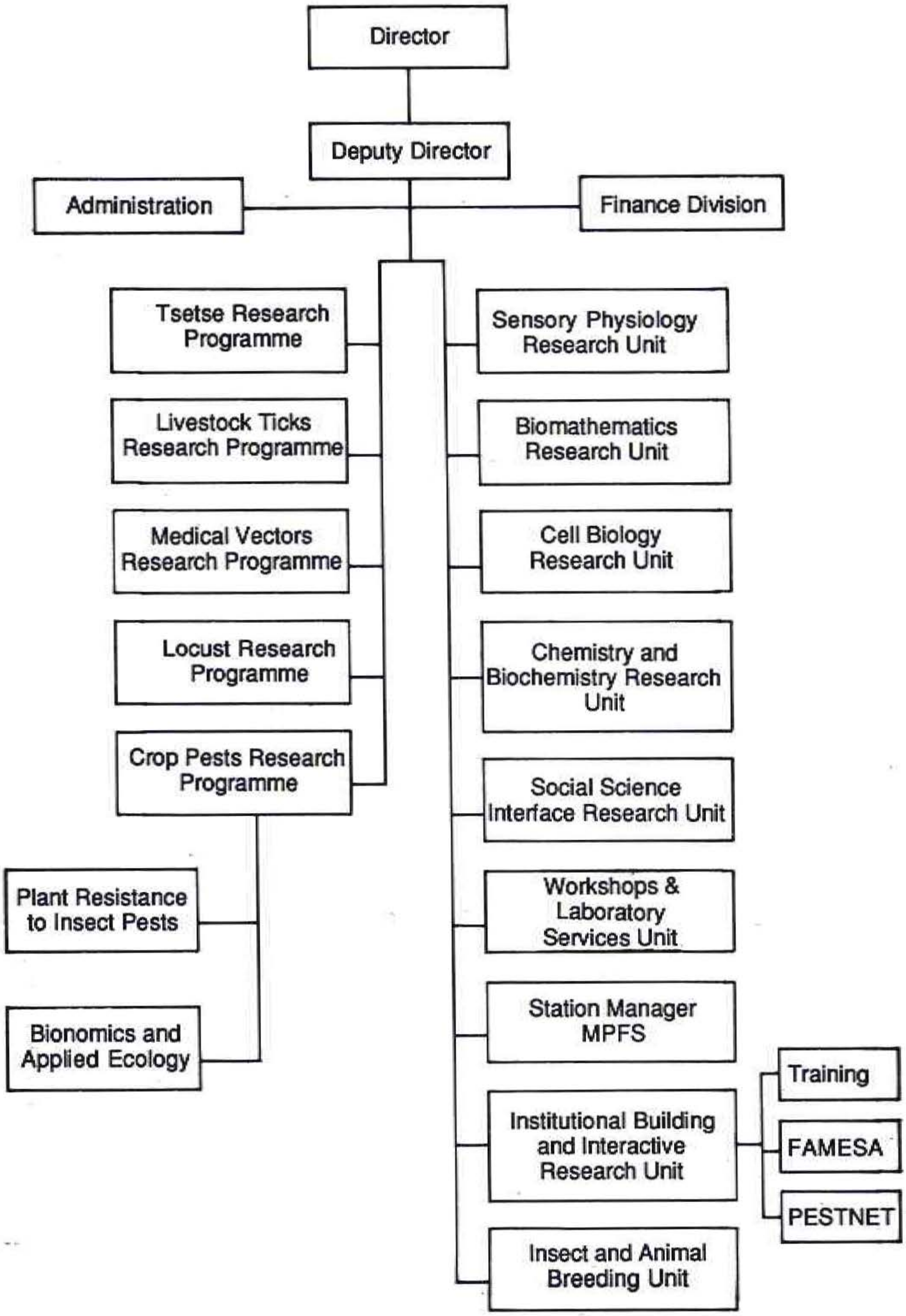

Figure 1. *Structure of ICIPE in 1991*

Appendix I

ICIPE WORKSHOPS & LABORATORY SERVICES UNIT (WLSU)
APPLICATION FORM FOR PURCHASE OF EQUIPMENT

TO BE COMPLETED BY APPLICANT

Project/Programme/Unit .... Vote No. ....

Applicant .... Date..

Approved/Not Approved by Vote Holder ....

DESCRIPTION OF EQUIPMENT

1. Name .... Make .... Model/Type ....
2. Have you a preferred Manufacturer? Yes ❑ No ❑
   If yes, please give reasons ....
   ....
3. Use of Equipment (Please give as many details as possible)
   ....
   ....
   ....
4. Location of Proposed Equipment...
5. Date Required ....

TO BE COMPLETED BY WLSU

6. Is this type of equipment available at ICIPE? Yes ❑ No ❑
   If yes, please state Programme .... Location ....
   ....
   ....
7. Is the suggested Manufacturer suitable? Yes ❑ No ❑
   If no, please suggest alternatives and state reasons, (cost, availability of spare parts, ease of maintenance, etc.)
   ....
   ....
   ....

8. Will this equipment require special services, e.g. Steam, Compressed Air, Gas Power Stabilisers, U.P.S. etc.

....

....

9. Will this equipment require specialised Maintenance/Operational Training?
   Yes ❑ No ❑
   If yes, give details of costs, etc. (if possible) ....

....

....

10. Are there Agents available in Kenya for the proposed Equipment?
    Yes ❑ No ❑
    If yes, give name, address and technical competence

....

....

11. Any Quotations/Pro-Forma Invoice available Yes ❑ No ❑
    If yes, give details and attach copies

....

12. State whether purchase is in Kenya or Abroad ....

13. Date of request for Quotation/Pro-Forma Invoices by PCTS ....

14. Remarks on Quotation/Pro-Forma Invoices ....

....

TO BE COMPLETED BY PROGRAMME LEADER

15. Comments on Workshops response ....

....

....

TO BE COMPLETED BY SUPPLIES SECTION

16. L.P.O. Number .... Date ....
    Expected Delivery Date ....

17. Date Equipment Received .... Signed ....
    Store Keeper

18. Equipment handed to ....
    Applicant Date

Orig – PDU
2nd – Workshops
3rd – Prog/Unit

PROCUREMENT OF SCIENTIFIC EQUIPMENT IN AFRICA*

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Introduction

Every scientific institution, be it research- or service-rendering, should be concerned with the efficiency, effectiveness and quality of the equipment that it procures in order to obtain the maximum benefit and service possible for the money invested. This is of great concern particularly to African countries, where resources are meager and budget allotments insignificant. Equipment and supplies are sometimes obtained through donations, however these contributions are often insufficient. Since donations are not always available and the equipment acquired in this way have their own inherent problems, nearly all African countries rely upon purchasing the equipment they need. However, with the wide variety of scientific equipment being marketed and the rising costs, it is highly essential that scientific institutions appreciate the need and importance of proper procurement procedures.

Role of Equipment and Supplies in Project Preparation and Planning

Most projects require the acquisition of certain essential equipment and supplies. They also require proper planning and defining the course of action needed to bring the project to completion by efficient use of time and facilities. In order to effect this and achieve the desired objective, the proper selection and purchasing of equipment and supplies is highly important. This enables one to learn about the applications of the equipment and make reconditioning of it whenever necessary.

What usually happens in the developing countries in general and in Africa in particular, is that orders are not made well-enough ahead of time.

Often there is failure to comply with the correct purchasing procedure and inadequate specification of equipment, causing a delay in the delivery time. Essential operation manuals may not be available. These delays cost extra time and money, resulting in a negative effect on the whole programme as well as on the personnel. This is a major factor that often hinders or brings about the complete suspension of many projects.

Role of Existing Infrastructure

It is a fact there is a continuous growth of infrastructure in all sectors of development programmes in Africa. However, as a medical technologist from Ethiopia, I should like to comment on a few things about the existing health infrastructure in Ethiopia in particular, for it more or less reflects the conditions in most other African countries. As in other development sectors, the health infrastructure in Ethiopia, *except in the equipment area,* is undergoing a steady growth in order to increase health coverage in the country. In contrast to this there has been only very little development in the sphere of equipment purchasing, maintenance and repair. The only maintenance and repair centre in the country, sited at the Tikur Ambasa (Black Lion) Hospital, is always deficient in replacement parts and skilled manpower. There is as yet no school in which to train maintenance and repair technicians.

Although there is growth of infrastructure in the other sectors of the health service, there seems to be no collaborative work being done, simply for lack of proper organisation. Pooling of resources for mutual benefit such as for group purchasing of equipment and supplies is not being materialised. In light of this, I feel that African countries should reorganise the existing infrastructure if their objectives are to be realised.

Knowledge of Suppliers

An efficient business of selling equipment and supplies requires *(i)* a good understanding and sound knowledge of the condition and facilities under which the equipment and supplies purchased are utilised, *(ii)* the suitability of the equipment to the particular region or area, *(iii)* the availability of maintenance and repair facilities or technicians, and *(iv)* the existing administrative support. These would enable both the supplier and purchaser to make re-adjustments readily whenever the need arises, and would help avoid misunderstandings. Sometimes, lack of this knowledge on the part of suppliers has resulted in a lot of constraints in the procurement of equipment, installation and later in their utilisation. Purchasers should also have a reasonable knowledge of suppliers, their products and terms.

Proper Budgeting

A well-conceived budget is essential to the successful management of a scientific establishment or laboratory, however, the fast technological advancement and increasing costs of equipment has become a serious challenge to the majority of African countries. Naturally, proper allocation of a capital budget for the purchase of equipment and an operating budget to cover supplies, spare parts, maintenance and repair services, as well as training of maintenance technicians is essential. These should be worked out in detail.

Such an arrangement has not been practical in most of the African countries. In Ethiopia, for instance, most of the health institutions under the Ministry of Health have no specified budget, particularly for laboratory services or for purchasing equipment. The budget allocated is for both pharmaceuticals and laboratory services in general, without any specification as to what amount is allotted to which. Most of this budget is usually spent on pharmaceuticals at the expense of the laboratory service. Thus, the purchase of laboratory equipment and spare parts is becoming a difficult matter to achieve. I suppose the same problem also exists in institutions that are outside the health sector.

Equipment Specification Schedule and Purchasing Procedure

The guidelines for specification of a piece of equipment include:

Instrument
Site preparation
Delivery and installation
Safety standards
Conditional period
Manuals
Services

An important factor that manufacturers and suppliers of equipment should consider are the environmental conditions in which the equipment is being used. The high temperature and humidity of most African countries are often the cause of defects in equipment and supplies. A thorough study of these conditions by the manufacturer helps a great deal to produce equipment which is capable of operating under specific environmental conditions.

Individual laboratories in the Ethiopian health service do not place orders directly to the manufacturer or supplier of equipment; they only obtain them from the Central Medical Store, and such a guideline is not employed. Only some autonomous and larger institutes practice a proper specification schedule. For instance, the University and the National Research Institute of Health who have access to foreign currency and bank permits, often place orders of equipment and supplies on the basis of specifications obtained from the manufacturer's catalogue and therefore have no problem in this regard.

In these institutes, a purchasing officer takes care of all requisitions made by the various departments within the institute. He then places the orders directly to the supplier within the country or often abroad.

Installation, Commissioning and Training

Installation of purchased medical equipment in Ethiopia is usually handled by the Techno-Centre which is the only place where maintenance and repair of all types of medical equipment is carried out. Even though this Centre is established to carry out this enormous task, the number of its technicians is insignificant when compared with the existing large number of health institutions requiring the service. Since no appropriate budget is allotted to the Centre, it is always in difficulties as far as fulfilling its duties is concerned. This sometimes results in the rusting and rotting of damaged or faulty equipment for lack of spare parts. Therefore the Centre requires strengthening.

Installation of equipment would also be ideal if a Central Store adopts a system with features which include

- advising on the effectiveness and efficiency of any equipment purchased;
- employment of adequate staff to check the equipment;
- provision of trained equipment technicians to install the equipment correctly;
- provision for a laboratory to return to the Central Store a piece of equipment that has been damaged in transit and to receive a replacement speedily.

Unfortunately,the Central Store in Ethiopia is not organised to deal with such responsibilities.

TRAINING OF MAINTENANCE PERSONNEL

A scientific institution must have a reasonable degree of self-sufficiency as far as handling the maintenance and repair of equipment is concerned. To this end, all institutions must have properly trained maintenance technicians and operators. In addition, people having a higher level of training abroad could also be employed to work in a maintenance and repair centre at the national level. There should be some training to meet these requirements. To effect this the following arrangements are essential:

- Manufacturers of equipment must train some individuals on the maintenance and repair of purchased goods. The training place could be the factory or a training center run by the manufacturer.

- A national training centre for training personnel capable of meeting the manpower requirements in the field of maintenance and repair of scientific equipment must be established.

The commissioning of the Central Store and the Training Centre must be done by the government.

Recommendations

Finally, I would like to forward the following recommendations, hoping that most of the problems associated with the procurement of scientific equipment in Africa can be solved:

- Sales representatives of manufacturers and suppliers should make regular visits to countries or departments using their products.

- A good relationship between the purchasing institute or department and the supplier can mean a fast turn-around time for equipment ordered.

- The manufacturer's operation manual is a good reference source; this must be provided by the manufacturer or supplier. Publications on scientific instrumentation are also useful.

- Institutions must initiate preventive maintenance programmes for equipment.

- Group purchasing should be initiated so that volume discounts are obtained.

- Purchasers should receive sufficient information from the manufacturer or supplier before placing an order; for example, ordering information, description of goods, current prices, expected delivery time, details of installation, demonstration, guarantee and service arrangements.

*This paper was not presented (read) at the Workshop, but the organisers recognise its importance and have therefore included it in these Proceedings

GENERAL DISCUSSION ON PROCUREMENT OF SCIENTIFIC EQUIPMENT IN AFRICA

Discussion Panel Members:	A. Abdinaser	–	UNESCO, Kenya
	J. M. Ngundam	–	Cameroon
	A. Djana	–	Djibouti

Abdinaser, *UNESCO, Kenya:* Emphasis should be placed on standardisation of scientific equipment and instruments. We need to think about future maintenance and the short life arising from obsolescence.

Ngundam, *Cameroon* (on Tadros paper): Instrumentation Centre functions should not be limited only to procurement and repair and maintenance, but should include such functions as acquiring and disseminating new technologies such as on manufacturing processes, producing quality goods at affordable prices, and being centres of excellence and research on new technologies.

Djana, *Djibouti:* We need to ensure a linkage between finance and administration. The limited finances available calls for the need for special fund allocation for equipment. Many instruments and equipment acquired through donor funding and the procurement of these is linked with certain suppliers. The complexity of equipment in Africa need not be to the same level as that in the developed world.

Nyambala, *CAPA, Kenya:* My question is about ICIPE's 3000 or so discrete instruments and equipment. This requires a huge stock-pile of spares to repair and maintain. How is this managed?

Answer: Spares are kept for only a limited number of instruments. The Disposal Board revises the inventory in an annual evaluation exercise and regularly recommends the disposal of some unserviceable instruments and equipment.

Nyambala: I would also like to point out that there is a need to vet and evaluate equipment suppliers, possibly on their previous attitudes, e.g., on provision of service manuals, on the range of spares they stock, etc. There is also a need to inspect the equipment procured, as some suppliers are known to supply obsolete equipment, while others recondition used equipment and deliver them as new.

As a matter of interest, how does ICIPE control its research findings and other products?

Answer: *ICIPE* is evolving an intellectual property protection system. There is an in-house committee, dealing with property protection and licensing policy which is addressing this issue.

Gardos, *IAEA, Vienna:* An inventory list of 3000 items would take one month to read through manually, allowing 5 minutes per item. Inventory alone does not solve instrument problems.

Comment (Mando, *ICIPE*): The essence of an inventory is that it

- provides an information base (knowledge of equipment, manufacture, cost, location, etc.);
- leads to standardisation on manufacturers (over 700 in the ICIPE case);
- leads to preparation and implementation of preventive maintenance schemes.

Lungwecha, *Tanzania*/**Oguntoyinbo,** *Nigeria*: How does ICIPE cope with the user/scientist conflict and with donor terms in equipment procurement? What are the effects of dwindling funding and government policies?

Answer: ICIPE is no exception to donor firms in equipment procurement. Sometimes equipment comes with scientists from donor countries. Scientist/user bias still exists but is greatly reduced with the new policy requiring WLSU involvement in the procurement process.

Gurkok, *UNIDO, Vienna*: On Donors :It is always a condition with most donors that equipment be acquired from their countries. Recipients can still get the best equipment from the countries by

- involving themselves in the preliminary specification stage, and undertaking a thorough scrutiny of catalogues, manuals, etc.;
- getting access to data bases/catalogues from several suppliers within the donor country. This ensures getting the best from the

country, without necessarily using those suppliers recommended by the donor;

- participating fully in the funding process.

Taylor, *IAEA, Vienna*: A survey done by the EEC on various donors shows that donor countries are not themselves specialists in the equipment they provide. They rely on the recipient's specifications. Usually the recipients do not bother to specify their requirements when requested by the donor. The donor agency then either prepares the specs or leaves it to the manufacturer (supply to fix).

Dirickson, *Brazil*: On the extra requirements necessary for equipment installation, equipment may be ordered and procured without taking care of other requirements such as power supplies, the working environment, etc., which may mean equipment staying down un-installed for a long period of time.

Menyhard, *Hungary*: If it is available, a computer-based maintenance system is an important aid in preventive maintenance schedules. It requires a basic number of staff, however.

It would be advisable to consider having service contracts with suppliers where possible, preferably with arrangements to upgrade the knowledge of service technicians as well.

It is also important to consider ordering accessories for the equipment, right from the procurement stage.

Akonde, *Kenya*: At the same time, it would be helpful if the manufacturer/ supplier would identify failure-prone components and provide the spares to run the equipment for a reasonable time period.

Oyuga, *Kenya*: Africa does not manufacture equipment and has severe financial constraints. The procurement of new equipment for research and other activities is, therefore, not a priority as concerns foreign exchange allocation.

Okoyo, *Kenya*: Solution of the dual problems of standardisation in the face of fast technological changes and donor controls has no unique formula and will be difficult to achieve.

Nyambala, *Kenya*: Is it ICIPE's mandate to help out African countries?

Answer (Mando): No. But we carry out collaborative work, such as maintenance of scientific equipment for the Coffee Research Foundation in Ruiru and the Tea Research Foundation in Kericho. Establishment of an Instrumentation Centre will enhance these activities.

Namukolo, *Zambia*: We in Africa need to train our service personnel on sophisticated and expensive equipment, rather than relying on bringing in experts from the manufacturers.

Mzengeza, *Zimbabwe*: It would be advisable to include administrators, planners, etc., in Workshops of this nature, since policy matters on procurement lay in their hands.

Ngundam, *Cameroon*: Government-funded institutions are more prone to donor interference, but institutions such as the ICIPE should be able to exercise some independence.

Djana, *Djibouti*: There is a critical need for scheduled preventive maintenance, and manuals and circuit diagrams are especially necessary. There is also need for user training on basic first-level routine maintenance, and a need to identify particular suppliers with whom one can establish and maintain relationships, for ease of procurement.

Ngundam, *Cameroon*: How can we in Africa cope with the continuously changing state of the art in instruments and equipment?

Answer: New technologies are rather difficult to handle, and a number of manufacturers do not send repair manuals. It is best not to go in for new, untested technologies in Africa. Older technologies, where it is easier to obtain the required manuals (depending on one's relationship with the manufacturer/supplier) are better for us.

Kimani, *Kenya*: I should point out another problem: a scientist's attitude towards maintenance technicians is often that of negligence.

Oyuga, *Kenya*: Are there spare parts available at the ICIPE for newly bought equipment?

Answer: Some spares are not bought immediately on purchase of new equipment. Most spares are bought on experience. Spares are not always stocked, and the level of availability depends on the equipment count and the importance attached to the instrument.

CHAIRMAN'S SUMMARY

- Standardisation of equipment is difficult but important.
- Effective linkages between finance and administration must be ensured.
- Donor funding requirements and procurement by donor agencies lead to maintenance and repair problems.
- Procurement procedures must be established properly.
- User bias for purchasing a specific make can be a problem.
- Service contracts with suppliers should always be considered.
- Spares should be obtained at the time of instrument procurement.
- Training of service personnel during procurement should be undertaken.

SESSION II

REPAIR AND MAINTENANCE OF SCIENTIFIC EQUIPMENT

CHAIRMAN: C. Gurkok

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MAINTENANCE OF SCIENTIFIC EQUIPMENT: EXPERIENCES OF THE NATIONAL RESEARCH CENTRE (CNR) OF MOROCCO

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Maintenance and repair play important roles in the safeguarding and the optimum use of scientific equipment. This role becomes more efficient when the maintenance personnel are associated with the design and development of electronic devices needed in numerous and specific applications, such as interfacing different kinds of apparatus, and reconditioning of old or used equipment.

For all these reasons, the Scientific Instrumentation Laboratory (LIS) of the National Research Centre (CNR) of Morocco has set up two activities: maintenance and microelectronics. The LIS has now gained good experience in offering different kinds of services to national users, either from the public or the private sector. This paper defines also the dynamic concept and the methodology and then describes our experience in the field of maintenance. Some concrete examples and the problems encountered are briefly presented.

Short History of LIS

Created by the Administrative Council of the CNR, the Scientific Instrumentation Laboratory (LIS) was set up in 1985. It has a two-fold mission: that of a scientific and technical service and that of a research laboratory. Its main mission is to master scientific and technical equipment and microelectronics through skilled training and setting up of appropriate facilities. This will contribute to a more efficient use of investment in the public and private sectors. The creation of such a mechanism is the result of fruitful cooperation with the United Nations organisation, notably the United Nations Development Programme (UNDP).

The LIS is currently endowed with the structures and means to offer to public institutions and private firms quality services in the areas of microelectronics and maintenance of scientific and technical equipment.

The services which are offered by the LIS to its clients (who are increasing in number and becoming more demanding), have been enlarging in scope over the years. Agreements and contracts are made in most cases with these partners.

Maintenance: Concept and Procedures

CONCEPT

Nowadays, there is a ceaseless trend towards more automatisation and more technological sophistication in scientific and technical equipment. Thus, the concept of maintenance can not be static, but is dynamic.

First and foremost, *maintenance is a state of mind or a sort of mentality which must be cultivated and integrated into the socio-cultural fabric of a nation.* From this point of view, maintenance can be defined as the collective capacity of a nation to be willing to avoid hazards and failures and wastefulness due to under-utilisation of common wealth and working tools.

From a technical point of view, maintenance consists of the collective actions which are necessary to maintain or to re-make an equipment in a specific state in order to ensure a well-defined service.

All these actions, both technical and administrative, are formulated in accordance with the equipment pool characteristics and the conditions of the working environment. The actions have to be revised and adapted, whenever it is necessary, due to techno-economical data variations in order to optimise the maintenance efficiency. According to this concept and to the specifications of the equipment pool, maintenance can be considered as a dynamic system to be optimised.

In the case of the LIS, maintenance is defined as a function covering the following activities:

Correct choice of technologies
Quality control
Preventive maintenance and periodical control
Repairs
Adaptation to the local ambient conditions
Rehabilitation
Calibration
Design and fabrication of interfaces and electronic devices for specific applications
Management

Knowing that only human resources can guarantee the mastery of technology and every maintenance policy success, the training of skilled maintenance staff is a question of capital importance and takes up a large part of our activities.

PROCEDURES

The procedures generally undertaken when providing maintenance service to any institute, consist of the following:

- Inventory of the apparatus to be maintained and establishment of a proper file for each one.
- Acquisition of the necessary technical documentations for repair and preventive maintenance.
- Diagnostics and repair of faulty apparatus.
- Establishment of a periodical servicing and preventive maintenance schedule.
- Checking on calibration.
- Being sure that the manipulators know how to use the apparatus.
- Training (on-the-job) the client's technical staff.
- Computerising the management of maintenance.
- Analysing purchase and guarantee arrangements.
- Sensitising the clients about the benefit of maintenance and post-investment within the framework of seminars, meetings, roundtables, conferences.

Design and Development of Electronic Devices

Design and development constitute a complementary way to enhance the maintenance efficiency of equipment and to adapt its techniques to the fast technological changes occurring. It is also another way to enlarge the circle of our clients, notably from the private sector. It is worth underlining here that, for private firms, the major problem of maintenance lies essentially in electronic servicing and testing of laboratory equipment.

Presently, the topics which are being developed in the field of modern electronics or microelectronics consist of (i) computer-aided design (CAD) of electronic circuits, and (ii) micropackaging. The micropackaging deals with the integration of hybrid circuits, thick films and surface mount technology (SMT) and printed circuit boards (PCB). All the different processes, from CAD to final tests, which deal with designing and constructing an electronic circuit are carried out locally by the staff of the LIS.

The main application fields of these technologies are maintenance, telecommunications, industry and scientific research. Having the means to modern equipment and experienced researchers, the services offered are being extended beyond maintenance to developing local skills in microelectronics (design and development of prototypes).

Examples of Some Positive Results

The efforts invested in setting up the maintenance activities have been successful and have led to concrete and interesting results. For example, the breakdown rate of the equipment pool at the children's hospital in Rabat was reduced from 21% to 5%. The remaining faulty apparatus (5%) were not repaired for many reasons, including lack of technical documentation and spare parts. Some apparatus were technologically very sophisticated and demanded a specialised training in their repair.

The prime cause of the equipment breakdown is due to misuse. Indeed, more than 50% of malfunctions are due to the users and are generally not very difficult to repair. (Comparatively speaking, the misuse breakdown rate is more than 30% in the health sector in France).

The yearly maintenance cost in the hospital is around 4%. This ratio is very interesting in comparison with that of private companies which is surely greater than 15%. However, it is very difficult to evaluate costs in the private sector due to lack of data.

Another example of a successful result related to the field of microelectronics can be mentioned. It consists of the design and fabrication of an interfacing unit for adaptation between two different kinds of apparatus (printer and balance from two different manufacturers), in order to automate measurement processes and, consequently, to enhance the equipment pool productivity.

The training of maintenance staff is of prime importance to the success of a maintenance programme. Besides the on-the-job training of users' technicians, seminars and courses are organised. For example, one can mention the "Regional Training Course on Nuclear Instrumentation Maintenance" which was organised in cooperation between LIS-CNR and the International Atomic Energy Agency (IAEA), from 4 June–13 July 1990 in Rabat. This course was dedicated to training 20 engineers and technicians from the African states who are members of the IAEA.

Presently, 15 institutes from the public and private sectors and belonging to different domains (health, telecommunications, agriculture, universities) are benefiting from the services offered by the LIS.

Difficulties Encountered in Maintenance

It is normal to encounter difficulties, especially in the field of maintenance. Sometimes it is possible to find solutions, but other problems still exist and perhaps will remain for a long time. The more serious are listed as follows:

- Difficulty in recruitment of technicians and absence of motivation in the public sector, which is characterised by low salaries in comparison with the private sector.

- Lack of the technical documentation needed for maintenance. This should be strongly requested and obtained at the time of delivery of the new equipment.

- Spare parts and components. The difficulties exist at different levels: administrative or acquisition procedures are lengthy and cumbersome even when the components exist in the local market. The maintenance budget is generally insufficient.

- Lack of any maintenance policy and mismanagement; especially in the public sector, the situation is generally quasi-dramatic.

Recommendations

Lessons generated by this experience lead to the following recommendations:

- Consider maintenance needs from the outset in any proposal for equipment purchase and ensure budgetary provision for them.

- Analyse existing problems before considering specific purchases.

- Train both equipment users and technical maintenance staff.

- Define a programme of maintenance and adapt it according to the evolution of new data.

- Seek out complementary sources of motivation and incentives to retain trained and skilled staff.

- Take any opportunity to undertake applied research in order to improve maintenance efficiency and to contribute to staff motivation.

Conclusions

The LIS is aiming at being more independent of government financial contributions and should consider alternative ways for becoming self-sustaining. To fulfill this aim, it is vital to develop a rational approach regarding maintenance and research development.

The services offered should be more attractive and diversified and of high quality. For all these reasons, the association of maintenance and microelectronics is considered to be interesting from different points of view:

- Improvement of maintenance efficiency

- Improvement of technical level of staff

- Enlargement of the service spectrum by diversifying the services offered mainly to the industrial sector, such as (i) advisory and expertise, (ii) transfer of knowledge and technology, and (iii) training of skilled researchers and technicians.

The creation of applied research topics, such as microelectronics, contributes not only to increasing the effectiveness of maintenance, but also to making the working conditions more attractive for at least two reasons: the development and improvement of applied research capabilities and the generation of supplementary extra-income earned from service contracts. This income will contribute towards motivating the laboratory staff and to consolidating its structures.

THE STATE OF CALIBRATION SERVICES IN KENYA

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Introduction

Scientific research and exploration, the search for new laws of nature, the investigation of microcosms and the cosmos, the ocean and outer space, medical and biological studies-all of this is inconceivable without measurements. The capabilities of a scientist to investigate, analyse, monitor and use natural phenomena depend fully on the measuring instruments and techniques available to him. It is equally true that no production process can do without measurements. Mass production, which is the basis of modern industry, relies entirely on the use of interchangeable parts measured with high accuracy.

The enormous amount of data and information obtained as a result of measurement, will, however, be meaningful and useful only with the indispensable condition that all measurements are correct, irrespective of the location, time and conditions under which they are performed. This desirable goal is achieved through a process of instrument and equipment calibration in a well-established national measurement system which forms a vital component of a national standards infrastructure.

This paper examines the state and organisation of calibration services in Kenya with special reference to the facilities and activities of the Kenya Bureau of Standards (KBS). Definitions of the process of calibration and its associated concept of traceability together with a few other terms which are pertinent to this discussion are listed in the Appendix to the paper.

The Need for a National System of Measurement

Testing and measuring instruments and equipment which are used in the areas previously enumerated in the introductory section of this paper should have their accuracy periodically certified through calibration against more accurate standard instruments. Accordingly, the standard instruments should have their calibration traceable to the measurement standards maintained by the National Measurement Laboratory of the country. The National Measurement Laboratory is responsible for maintenance of National Measurement Standards, i.e., provision of apex calibration and development of measurement technology. It is usually a government laboratory.

But how does a National Measurement Laboratory know that its standards are correct? Since by a national official decision there is nothing better than and above a national standard in a country, the only way of checking is by comparison with standards of other nations. The organisation of such comparisons is one of the tasks of the International Office of Weights and Measures (BIPM) in Paris. It is hence evident that National Measurement Laboratories can not live in isolation, but must be integrated into a system which enables and facilitates comparison measurements and guarantees uniformity of the units on a global scale.

This same principle is demanded at the national level for all measurements and provides the *raison d'etre* for the establishment of a national system of traceable measurements. "To measure is to compare a quantity with another quantity of the same type taken as a reference." It is at once, therefore, clear, that in the absence of any reference or standard, any measurement is impossible. Also, if the reference or standard is not the same for everyone, then the results of measurements become meaningless. There is therefore obviously a need for a means to enable users of instruments to refer to common measurement standards. This means is afforded through instrument and equipment calibration in a well-ordered hierarchy of measurement standards at the national level in what is commonly called a National Measurement System.

Calibration can, therefore, be viewed as a process by which the operational integrity of instruments is verified. Compatibility, high accuracy and economy of all measurements require measuring instruments to be related in a clearly defined manner to reliable and highly accurate standards, that is, national standards. In concrete terms, the measuring instruments in the field or on the factory floor or in the laboratory should be periodically calibrated against the standards of the company or organisation or institution concerned, and these standards in turn should be correctly calibrated by a public or private organisation or the national standards institute in an established calibration system. Such a system is called a traceability system. Traceability, however, does not merely provide standard instruments calibrated against national standards, but implies also related measuring technology, the concept of standard control and management and training to acquire technical skills. In addition to providing a means of fulfilling the requirements of traceability to national standards, calibration makes it possible to achieve accuracy, precision and interchangeability by minimising the uncertainty associated with measuring instruments.

In summary, it is seen that essentially a National Measurement System must have the following components:

- laboratories for maintaining national measurement standards, providing units of sufficient accuracy to serve industry, commerce and the scientific community and to ensure that the national standards are compatible with the SI system;

- a practical system for ensuring that the measuring standards, and instruments used in industry, commerce, science and technology are traceable to the national standards.

A basic scheme for a National Measurement System is depicted in Figure 1. Most industrialised countries have these facilities. However, the organisational details differ from one country to another to suit her own particular needs. The situation in developing countries and especially in Africa is, however, far from satisfactory. According to a recent study by the Africa Regional Organization for Standardization (ARSO) among its member States:

> "Metrology infrastructure and facilities are barely developed in the African region. Out of 23 ARSO member states, only three countries can be said to have comprehensive facilities and active implementation of legal and industrial metrology work. Work in the field of scientific metrology is carried out only in one member state".

The remaining part of this paper will, therefore, examine the state of instrument and equipment calibration services in Kenya, which was identified as one of the three ARSO member states with active implementation of legal and industrial metrology activities in the study cited above.

Instrument And Equipment Calibration Services In Kenya

RESPONSIBLE NATIONAL INSTITUTIONS

In Kenya, metrology activities at the national level have been entrusted to two institutions. Legal metrology is the responsibility of the Weights and Measures Department which operates under the Weights and Measures Act Cap 513 of the Laws of Kenya. This is a government department within the Ministry of Commerce. Scientific and industrial metrology activities are run by the Kenya Bureau of Standards which is a statutory organisation of the Government and operates under the Standards Act Cap 496 of the Laws of Kenya with the Ministry of Industry as the parent ministry. Repair, servicing, maintenance and calibration of scientific instruments and equipment fall mainly within the domain of scientific and industrial metrology, hence attention will be focused only on the activities of the Kenya Bureau of Standards.

ESTABLISHMENT OF THE KENYA BUREAU OF STANDARDS AND ITS MANDATE FOR SCIENTIFIC AND INDUSTRIAL METROLOGY

The Kenya Bureau of Standards (KBS) was set up by an Act of Parliament known as the Standards Act, Chapter 496 of the Laws of Kenya, in 1974 as a statutory organisation of the Government with overall responsibility for Standardisation and all matters incidental or connected thereto. One of the functions of the KBS as spelt out in Section 4 (1) (b) of the Standards Act is "to make arrangements or provide facilities for the testing and calibration of precision instruments, gauges and scientific apparatus, for the determination of their degree of accuracy by comparison with standards approved by the Minister on the recommendation of the Council, and for the issue of certificates in regard thereto".

The KBS discharges this function through its Metrology Division which houses the national measurement standards laboratories and offers calibration services to industry, commerce and the scientific community either directly or through the National Calibration Service (NCS).

CALIBRATION SERVICES AT THE KENYA BUREAU OF STANDARDS

In line with the demands and requirements of the Kenya economy, the Kenya Bureau of Standards has developed a wide range of measurement and calibration facilities. These facilities are managed by the Metrology Division within the Bureau which is currently divided into four departments and one section. Each department has a number of laboratories as follows:

Department	Laboratories
Mechanics	Mass; Force; Torque; Pressure; Length; and Industrial measurements.
Electricity	DC standards; AC standards; Energy meters; Instrument transformers; Time and frequency; and Dosimetry (under consideration)
Instrumentation	Instrument repairs and maintenance; Instrument development
National Calibration Service Section	–

The various services offered by the above laboratories are listed in Appendix II of this paper.

INSTRUMENTATION DEPARTMENT OF THE KBS

This department ensures smooth and continuous operation of the other laboratories in the metrology division and also the biochemical and materials laboratories of KBS. The department is currently equipped to undertake maintenance of testing and measuring equipment. Due to lack of sufficient instrumentation facilities (both manpower and equipment) in this country, this department plays a major role in assisting industry, commerce and the scientific community in carrying out instrument repairs. The equipment repaired includes:

Medical & laboratory equipment	Industrial equipment	Telecommunications
Carbon-sulphur analysers	X-ray crack detection equipment	Oscilloscopes
Amino acid analysers	Textile abrasion testers	Oscillographs
Electronic balances	Textile evenness testers	Pulse generators
Spectrophotometers	Compression testers	Multimeters
Photometers	Temperature controllers	Transmitters
Autoclaves	Temperature gauges	Receivers
Chromatographs		
Ovens		

The National Calibration Service (NCS)

After a period of operation following the establishment of the metrology laboratories at the Kenya Bureau of Standards, it was realised that with time, the laboratories would perhaps not be able to cope with the large and continuously increasing number of calibration requests. Hence, it was decided to conduct a survey to determine who else in the country was offering similar services and how best they could cooperate with KBS to guarantee a high standard of calibration services. This was the beginning of the eventual establishment of the National Calibration Service (NCS).

ESTABLISHMENT AND OBJECTIVES

The National Calibration Service (NCS) was established by KBS in January 1984 through a gazetted notice which has since been amended once (1986) and is currently under consideration for further amendment to make it more appropriate and applicable to the Kenyan situation.

The main objectives of the service are to:

- establish a calibration hierarchy to coordinate calibration activities among various laboratories and ensure traceability of all measuring instruments to the national standards of measurement by periodic calibration;
- lay down uniform calibration procedures;
- ensure uniformity in reporting of measurement results;
- make recommendations on the level of accuracies for calibration laboratories at various echelons;
- assist in identifying measurement standards for calibration laboratories;
- organise regular intercomparison measurements among laboratories doing similar measurements through a measurement assurance programme;
- establish an accreditation scheme through which laboratories are recognised by the KBS as being capable of carrying out calibration work on its behalf;

- establish an information system on measurement facilities and organise training and seminars for personnel of calibration laboratories.

MEMBERSHIP IN THE NCS

Any firm, institution, organisation or body with adequate facilities, equipment and correspondingly qualified staff enabling it to carry out calibration work in a given field within specific levels of accuracy, irrespective of whether it be publicly or privately funded, can apply to become a member of the National Calibration Service. The conditions to be fulfilled by candidate laboratories are as follows:

- They must be in possession of the necessary measurement standards in the appropriate field(s) for which accreditation is being sought.

- The standards must be maintained under proper conditions.

- They must show proof of regular calibration of their standards through supporting certificates.

- They must have qualified staff capable of adequately carrying out calibration work.

- They must be able to issue certificates of calibration to their clients and keep records of all calibration data.

- They should be well-organised with well-planned working procedures to avoid any obvious mistakes during normal day-to-day calibration work.

A laboratory wishing to be accredited must make a formal application to the KBS stating the field(s) of measurement in which accreditation is being sought. The KBS will send its officers who are experts in those particular fields to carry out an assessment of the candidate laboratory. On completion of the assessment, the officers will make their recommendations as to whether or not the assessed laboratory meets the laid-down requirements. If not, then the laboratory will be informed and told of the shortcomings which if corrected, would enable it to meet the requirements. After undertaking the necessary remedial measures, a fresh application must be filed following the procedures mentioned above. If the recommendations are that the assessed laboratory meets the requirements, then the KBS will go ahead and issue it with an accreditation certificate. This certificate is valid for a period of one year from the date of issue. At its expiry, an application for renewal must be filed.

SUPERVISION AND INSPECTION OF ACCREDITED LABORATORIES

A scheme of supervision and inspection has been developed by KBS to ensure that the accredited laboratories maintain the same capability as at the time of accreditation. The KBS normally takes the following steps:

- It sends out its officers from time to time, without notice, to the calibration centres to check on their performance.

- Once a laboratory has been accredited, it is issued with special stickers, which it must stick on the instruments it calibrates. When KBS officers come across an instrument with such a sticker, it is immediately possible to know which calibration centre worked on it and by taking such an instrument back to the KBS laboratories and carrying out a check calibration, the results can be compared with those of the laboratory in question. KBS is then able through this process to assess how well the laboratory is carrying out its work.

- The KBS insists on recalibration of reference standards from all calibration centres at specified regular intervals.

- The KBS conducts audit measurements by circulating test pieces among calibration centres. The results are then statistically analysed and compared, and through this process, it is possible to monitor the performance of different laboratories.

In this process of supervision and inspection, if it is found that a particular laboratory no longer meets the prescribed standards, the accreditation certificate is withdrawn. Table 1 shows the calibration centres which are currently accredited under the National Calibration Service and Figure 2 depicts the hierarchical ordering of the measurement system currently in operation in Kenya.

Conclusions

Scientists and engineers need to make accurate measurements of parameters and quantities in conducting research and development work. This is only possible, however, with the indispensable condition that the instruments and equipment used are in proper working order. Hence, the enabling activities of repair, servicing and maintenance of instruments and equipment coupled with calibration, which ultimately guarantees the operational integrity of instruments and equipment, need to be given serious and due consideration at all times. It is of vital importance that each country should, as far as is practicable, develop adequate capabilities to provide measurement and instrumentation services required by the various sectors of its economy.

Table 1. *National Calibration Service (NCS) Accredited Centres*

Pos	Centre Number	Centre	Region	Field(s) of Measurement
1	S 14	SGS Kenya Limited	Mombasa	Volume/Flow
2	S18	Instrumentation Limited	Nairobi	Temperature Pressure Electricity (dc) Electricity (ac) Time & Frequency
3	S 19	United Import Agencies	Nairobi	Electricity (ac); Time & Frequency
4	T 27	Pump Maintenance (Kenya) Ltd.	Nairobi	Pressure Volume/Flow
5	T 30	Premier Agencies of Kenya Ltd.	Nairobi	Pressure Volume/Flow
6	S33	Pete Aviation Electronics	Nairobi	Electricity (dc) Time & Frequency
7	S 36	Kenya Steel Fabricators	Nairobi	Volume/ Flow
8	S 38	EngSales (Kenya) Ltd.	Nairobi	Electricity (dc) Electricity (ac) Time & Frequency
9	S39	Wilken Telecom-Communications Ltd.	Nairobi	Electricity (dc) Electricity (ac) Time &Frequency
10	S 40	Azicon Engineering Ltd.	Nairobi	Electricity (dc) Electricity (ac) Time & Frequency
11	S 41	Electrocom System Services Ltd.	Nairobi	Electricity (dc) Electricity (ac) Time & Frequency;

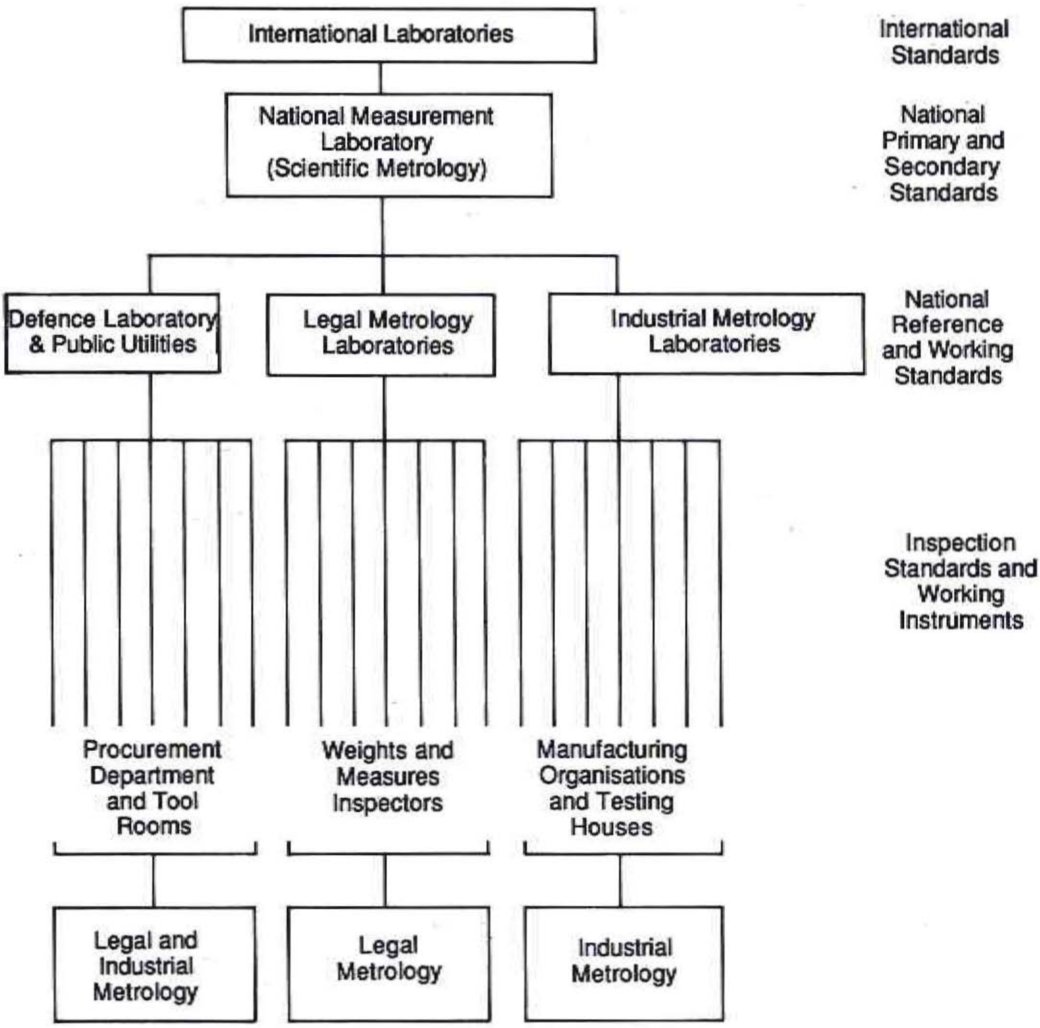

Figure 1. *A Basic Scheme for a National Measurement System*

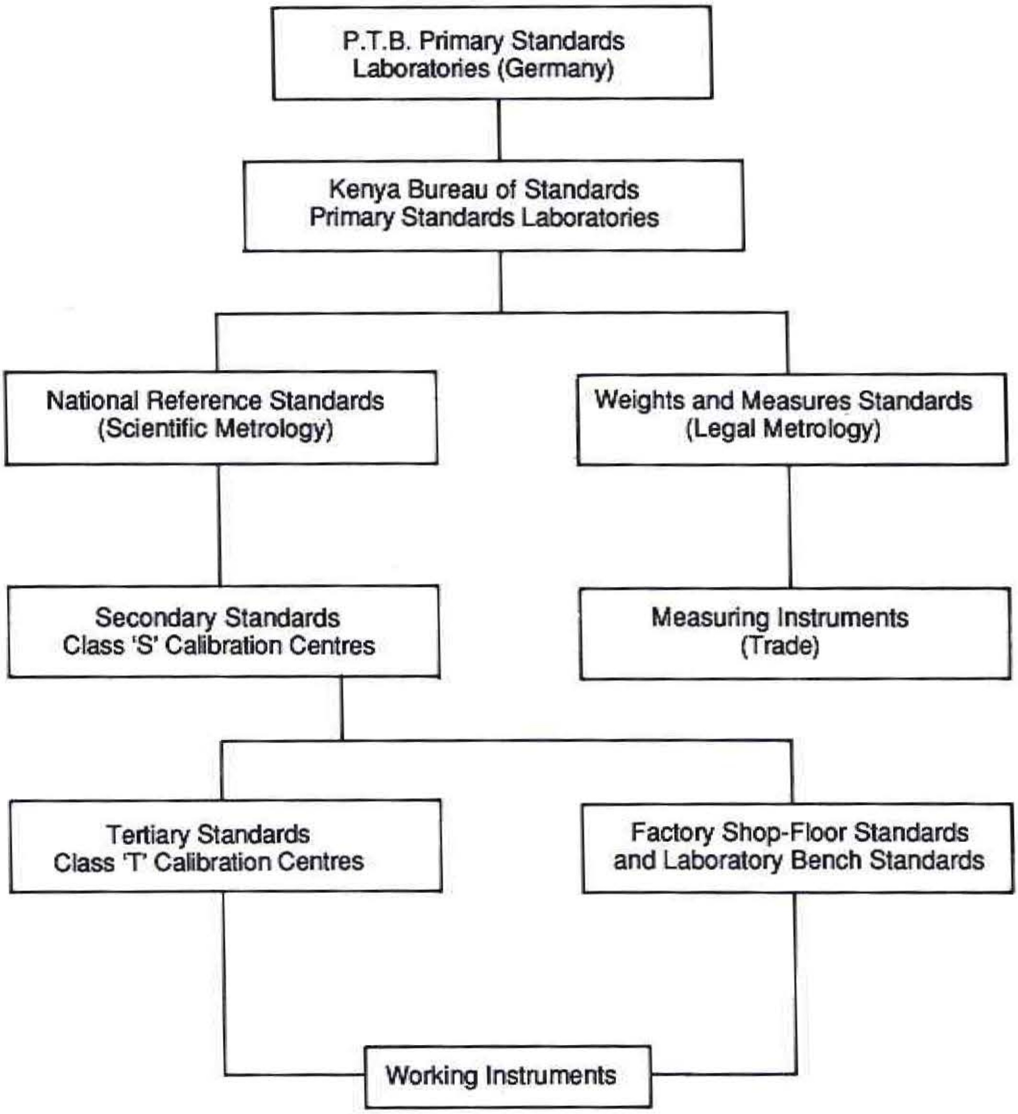

Figure 2. *Structure of the KBS/NCS Scheme*

Bibliography

African Regional Organization for Standardization (ARSO) (1989). *The Role of Metrology in Development* , ARSO publication.

Anritsa Electric Co. Ltd. (1980). Anritsa Accuracy Traceability System. Anritsa Pamphlet.

Bosire, W.E.M. (1987). The National Calibration Service in Kenya. Paper presented at KEBS Metrology Seminar 1987.

De Silva, G.M.S. (1990). Assistance to the African Regional Organization for Standardization (ARSO) in the Development of Metrology Activities in the African Region. Technical Report prepared for ARSO.

Fay, Eberhard (1988). Der Deutscher Kalibrierdienst : Ein Neues Element der Messtechnischen Infrastrucktur. PTB - Mitteilungen 98 1/88.

International Standards Organisation (1984). International Vocabularly of Basic and General Terms in Metrology, ISO publication.

Manyala, J.O. (1988). *National Systems for Ensuring Measurement Traceability.* Report of ARSO Workshop on Metrology, 5-14 December 1988, Addis Ababa, Ethiopia.

Appendix I

DEFINITIONS

Calibration: The set of operations which establish, under specified conditions, the relationship between values indicated by a measuring instrument or measuring system, or values represented by a material measure, and the corresponding known values of a measurand.

Measuring instrument: A device intended to make a measurement, alone or in conjunction with other equipment.

Measurement: The set of operations having the objective of determining the value of a quantity.

Measurement Standard (etalon): A material measure, measuring instrument or system intended to define, realise, conserve or reproduce a unit or one or more known values of a quantity in order to transmit them to other measuring instruments by comparison.

Metrology: The field of knowledge concerned with measurement. Metrology includes all aspects, both theoretical and practical, with reference to measurements, whatever their level of accuracy, and in whatever fields of science or technology they occur.

National Standard: A standard recognised by official national decision as the basis for fixing the value in that country of all other standards of the quantity concerned. The national standard in a country is often a primary standard.

Primary Standard: A standard which has the highest metrological qualities in a specified field. The concept of a primary standard is equally valid for base units and derived units.

Secondary Standard: A standard whose value is fixed by comparison with a primary standard.

International Standard: A standard recognised by an international agreement to serve internationally as the basis for fixing the value of all other standards of the quantity concerned.

Reference Standard: A standard, generally of the highest metrological quality available at a given location, from which measurements made at that location are derived.

Working Standard: A standard which, usually calibrated against a reference standard, is used routinely to calibrate or check material measures or measuring instruments.

Transfer Standard: A standard used as an intermediary to compare standards, material measures or measuring instruments. When the comparison device is not strictly a standard, the term transfer device should be used; for example, adjustable callipers used to compare end standards.

Travelling Standard: A standard, sometimes of special construction, intended for transport between different locations. For example, a portable battery-operated caesium atomic frequency standard.

Traceability: The property of a result of a measurement whereby it can be related to appropriate standards, generally international or national standards, through an unbroken chain of comparisons.

Unit (of measurement): A special quantity, adopted by convention, used to express quantitatively quantities which have the same dimension.

Value (of a quantity): The expression of a quantity in terms of a number and an appropriate unit of measurement.

Appendix II

SERVICES OFFERED BY LABORATORIES OF THE KENYA BUREAU OF STANDARDS

Laboratory	Reference Standard	Measurements carried out	Items calibrated/ tested
DC-Standards	Voltage; current;	Voltage (10µV-1000V) current (up to 100A); Resistance (up to 1 Mohm)	Ammeters; Voltmeters; Wattmeters; Potentiometers; Decade Resistance Boxes; pH meters; Standard cells;
AC-Standards	Capacitance; Inductance	Capacitance (up to 99 999 µF) Inductance (up to 99 999 H)	RLC bridges; AC standards; Aircraft liquid quantity gauges
Energy meters	Electronic Standard Watthour meters; Precision wattmeters		Single phase watthour meters; Substandard meters; Trivectors; Three phase watthour meters; Reactive power meters (Var-hour meters)
Time & Frequency	Rubidium atomic frequency standard; Avionics test assembly	AM/FM modulation, depth, frequency & phase deviation, RF power measurements for transceivers and transmitters (up to 1000W, 1 GHz); modulation distortion SINAD measurements. Receiver sensitivity, selectivity, blocking and cross modulation; Modulation characteristics VOR-ILS ground systems;	Frequency standards; Oscillators, signal generators; Frequency counters/ meters; Airbone VOR and ILS receivers (to RTCA and ARINC recommendations)

Time and Frequency		Direction of angle difference in resolvers and VOR generators	
Mass	Primary Kilogram Prototype balance; Torque meters		Standard weights; Precision balances; Torque wrenches; Torque meters
Force	Force standard machine; Standard load cells (up to 1000 KN)		Load cells; Proving rings; Aircraft weighing kit; Portable weighing bridges; Compression/ Tensile testing machines; Cube crushers; Tyre testing machines.
Industrial measurements	Set of gauge blocks (up to 100mm); Tesa gauge block stand; Three axes universal measuring machine; Perthometer C-D surface measurement system; Involute and helix angle measuring machine; Microptic autocollimator system	Length; Angles; Surface texture; Straightness; Roundness	Gauge blocks, External and internal threads; Tool jigs; Reference masters; Precision parts; Gears; Micrometers: Callipers; Dial gauges; Plug and ring gauges; Squares; Line Scales

Temperature	Liquid-in-glass thermometers; Resistance thermometers; Thermocouples; Ultra Kryostat U80 thermostatic bath (-80°C to -40°C); Tamsons oil and water thermostatic baths (100°C–600°C); Ovens (up to 3000°C)	Thermocouples; Ovens; Liquid-in-glass thermometers; Resistance thermometers; Temperature gauges
Volume/ Flow	Standard Volumetric tank (50 l) Secondary volumetric tanks (5-500 l) Conical flasks; Meter test bench; Gas flow test meters	Water meters (12.5mm to 200mm); Oil meters; Oil tanks; Mixing tanks; Volume containers
Density/ Viscosity	Primary viscosity standard fluids; Viscometers; Temperature baths and thermostats; Hydrometers	Repair and calibration of viscometers; Determination of density and viscosity of oils, paints, adhesives, varnishes and chemicals
Pressure	Hydraulic pressure standard (up to 1000 bar); Budenberg hydraulic standard (up to 4000 bar); Secondary standard pressure gauges.	Industrial pressure gauges; Tyre pressure gauges; Blood pressure measuring instruments (BP machines); Vacuum gauges

MAINTENANCE OF SCIENTIFIC EQUIPMENT AND SUGGESTIONS FOR SETTING UP A WORKSHOP

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General View of Maintenance Procedures

Scientific equipment can be generally grouped into four main categories:

(i) *Simple* - water baths, shakers, etc.
(ii) *Moderately complex* - stirrers, d.c. power supplies, etc.
(iii) *Complex* - centrifuges, electronic balances, spectrophotometers, etc.
(iv) *Very complex* - electron microscopes, scintillation counters, gamma counters, fax machines, etc.

The size of an institution or organisation and the nature of its work usually determines the complexity and the numbers of any one type of equipment. For example, a research station like ICIPE or ILRAD have a whole range of complex and even some very complex instruments. To cite a few examples: mass spectrophotometer, nuclear magnetic resonator, gas chromatograph, HPLC, electron microscope, ultracentrifuge. On the other end of the scale, a small regular clinical laboratory would probably have a haematocrit, a water bath or two, a light microscope and possibly a simple blood cell counter.

Large institutes would therefore employ technical personnel, but the level of expertise of the technicians would depend entirely on what the organisation expects of its personnel and its maintenance policy. Obviously, it would be unfair to expect wonders from a technician who has average qualifications and limited experience. If very complicated in-house repair work is not expected, then it is uneconomical to employ highly skilled technicians.

In developed countries the general trend is to employ in-house technicians to deal with the routine service and first-line repair work, e.g., replacing fuses, lamps, motor brushes, etc. Any service beyond that is usually left for an appointed agent or equipment manufacturer to deal with. Each service agent in these countries is best equipped to repair the particular brand of equipment in which he specialises. Moreover, spares would be available locally. Therefore, using outside service experts is obviously cost-effective, especially since the service is quick and efficient.

On the contrary, in developing countries the manufacturer or their service agents are unable to provide the same level of service that their counterparts provide in developed countries. The agents complain that they cannot stock a full range of spares and hire fully trained personnel to support the small volume of sales that they make. So in the end the local agent has to depend on their principals for spares and technical help. This causes undue delays, not to mention the additional delays encountered with import licenses and customs and excise authorities.

ILRAD's policy on Repair and Maintenance

In the early days, ILRAD did depend on outside service agents to repair equipment, but as the Institute grew, it became clear that the service provided was inadequate. ILRAD therefore recruited engineers and technicians to do most, if not all, of its service and repair work. Within two to three years, all the repair work was done in-house and apart from one or two specialised areas, no repair work is farmed out at the present time.

Needless to say, as far as ILRAD is concerned, the in-house approach has proved very successful, but not without sizable investments in three areas:

- employing well-trained personnel with broad electronic skills;
- having a workshop equipped with modest equipment and tools;
- stocking adequate level of spares.

Each of the above three objectives needs careful thought before implementation. For example, if the technicians are not selected carefully, there will be a quick turnover of personnel which does not benefit the department. Likewise, some spares are capital-intensive, and if not selected with due care can be a waste of resources, especially if the spare is never used. Purchasing unnecessarily sophisticated test equipment likewise ties up investment with little benefit. It is therefore prudent to seek advice and examine in-house maintenance in other similar establishments.

Unfortunately, ILRAD at that time was not in a position to draw on other local institutes' experiences. So whatever ILRAD has established may not necessarily be ideal for it, but over the years the system has been improving. Today it operates fairly smoothly, because ILRAD had been conscious of the following needs, outlined below.

TRAINING OF TECHNICIANS

Obviously, technicians are the most valuable asset of the service department. In order to get the best out of them, updating in new equipment, techniques and tools is of paramount importance. A good way to train technicians is to ensure that the training is received on equipment that the Institute actually purchases. This can be a two step-process:

Manufacturer Training: Training on equipment at the manufacturer's premises can be useful but its usefulness depends entirely on the technician's qualifications and ability to absorb the sophisticated technology in today's electronic instrumentation. Manufacturers will explain how an equipment works, but will seldom demonstrate repair of their equipment at the electronic component level. They have their reasons:

- Most manufacturers like to believe that the electronics of their equipment is trouble-free. This is true to some extent in most developed countries where a much more reliable and stable power supply exists. Therefore, electronic failures are certainly fewer in their environment.

- Modern electronic equipment is becoming increasingly complex for various reasons. Therefore, the manufacturers try to make the system modular so that repair is greatly simplified. As repair of modules to component level is time-consuming and therefore expensive, repairmen in developed countries opt for repair by replacement with new modules. Naturally, the repair technician in such instances does not need very much expertise.

- Some manufacturers are unwilling to release circuit diagrams which are essential if one intends to do repair work to component level. They fear that their designs could be copied by their competitors.

From time-to-time ILRAD has sent technicians to selected manufacturers for equipment training. These are manufacturers who supply us with large quantities of equipment, e.g., Heareus, Beckman. The technician is therefore exposed to different faults frequently encountered and enhances his practical knowledge.

In-house Training: All too often, a technician is expected to remember all that he is told by the manufacturer. Only a genius is capable of that. There is no substitute for hands-on experience and if this can happen soon after the manufacturer's briefing, the technician has a good chance of retaining what he has been told. Naturally, a station that does not have a sufficient volume of equipment cannot expose the technician to sufficient practical experience. Experience has shown that a lot depends on the technician's own initiative. A keen technician learns a lot on the job, especially if he has somebody to lean on when he has difficulty. Technicians acquire a sense of confidence if they are guided and offered inspired technical assistance in their job. Above all, technicians must be educated to recognise their capabilities and limitations and to ask for help where necessary. ILRAD can proudly say that it has tried to encourage and motivate technicians in this manner.

STANDARDISATION OF LABORATORY EQUIPMENT

Institutes and organisations would benefit if equipment is standardised wherever possible. The advantages are obvious — low spares costs, ease of back-up service due to familiarity, etc. Also, if sister institutes standardised, technical staff can exchange experiences and even in some cases loan spares to overcome problems until their own spares are available.

PREVENTIVE AND CORRECTIVE MAINTENANCE

Most instrumentation which has mechanical wear and tear needs preventive maintenance: cleaning, oiling of bearings, changing of brushes, belts, 'O' rings, etc. These are usually specified by the manufacturers. Preventive maintenance on electronic parts is usually limited, except perhaps to clear dust and change batteries. Lack of preventive maintenance on mechanical parts often leads to electronic failures. Experience has shown that electronic failures are few and most of them can be traced to lack of regular maintenance such as attending to spills, dust, loose contacts, dry bearings, to name a few.

At ILRAD a preventive maintenance schedule has been instituted. All equipment that has moving parts is checked on a regular basis, the periodicity depending on usage and safety; for example, ultracentifuges are checked monthly for oil consumption, cleanliness of vacuum pump oil, lubrication of vacuum seals, etc. The other parameters such as rate of cooling, speed calibration and braking are checked bi-annually or annually.

USER MAINTENANCE

This is a very important aspect of maintenance and should be the first line of maintenance. Educate the user so that he/she is aware of the proper care and use of equipment, e.g., sequence of operation, cleanliness and good habits. The user should also be alert to unusual noises or occurrences in the equipment and report to the person concerned before further use. Caution and dissuade the overkeen operator from doing repair jobs of a technical nature. Often, that leads to greater trouble.

DEDICATED ELECTRONIC WORKSHOP

Lastly, but not the least, the Institute has recognised the need to have a well-equipped workshop dedicated purely to the repair of electronic equipment. As and when the need arises, the test equipment is updated to meet today's electronic repair work.

Appendix

Setting Up a Workshop

A good workshop is essential to proper repair and maintenance, but in practice this is, unfortunately, rarely accorded the high priority it deserves, All too often, the planning of a workshop is somewhat haphazard and the engineers or users are seldom consulted. Below are a few points to consider when setting up a workshop.

Location

The workshop should be close to the area of work, but far enough away to avoid constant distractions or interruptions. It should not, however, be so far away as to be inaccessible.

Workbenches

Benches should be steady and of adequate depth and height. Recommended depth is usually 60–80 cms and height between 70–78 cm. A slightly higher level may be preferred if stools are used. The length will depend on the dimensions of the actual workshop but should be at least three to four times the depth. The benchtop should be covered with a hard-wearing and heat-resistant surface. Each bench should be provided with at least four mains outlets, preferably wired to earth leakage circuit breakers. Drawers on bench-side are useful to store tools, etc. A top shelf on the bench is useful to place test equipment out of the way from the work surface.

Storage

A busy workshop will have several pieces of equipment in various stages of repair. Some may be awaiting parts, service information, etc. It is essential that such equipment is carefully stored in purpose-built shelves until it can be attended to.

Consideration should also be given to storage of service manuals, operating handbooks, and history cards. Usually these can be stored in standard filing cabinets.

Commonly used tools and test gear such as multimeters, power supplies and test leads, should be stored in a handy place by the workbench so that work can be carried out with the minimum of inconvenience. Small storage bins are ideal for items such as I.C.'s fuses, resistors, etc.

Lighting

Undoubtedly the most efficient method of illuminating a large workshop area is with the aid of one or more fluorescent strip lights. A higher degree of illumination is desirable at the work area and is best provided by a counter-balance desk lamp. Such lamps can be rotated and extended into almost any position. In any event, local illumination must be considered essential if fine inspection work is to be carried out.

Security

Most workshops will house expensive equipment for repair and a host of test equipment and tools. It is therefore advisable at the outset to pay proper attention to adequate security.

Safety

No workshop can be complete if some mention is not made about safety. Due consideration should be given to protect personnel and equipment in case of fire and electrical shock. These are usually laid down by the relevant bodies and when a workshop is being set up, it is wise to consult the appropriate authorities.

Tools

Good quality tools can be expected to last a lifetime, provided they are properly used and cared for. So it is wise to invest in the best quality one can afford.

MINIMUM LIST OF RECOMMENDED TOOLS

Pair of side-cutters
Half-round nose pliers
Combination pliers and cutters
Set of 3 or 4 sizes of flat screw drivers
Set of 3 or 4 sizes of cross-point screwdrivers
Metric set of allen keys
Imperial set of allen keys
Set of 8-piece box spanners - metric
Set of 8-piece open or ring spanners - metric
Hand drill
General purpose soldering iron (15W to 18W)
Solder sucker

Test Gear

Not only will the range of test equipment available in the workshop dictate the type and complexity of service work undertaken, but it will also determine the ease with which it can be done. A good service technician gets to know his test gear extremely well. He soon knows which instrument to use for a particular application. Choosing the right instrument for the job can be all-important, and there are a number of pitfalls to be avoided. Familiarity is the key to getting the best from your test gear and, at least in the initial stages,it is wise to learn how to use one instrument at a time.

MINIMUM LIST OF TEST EQUIPMENT

Multimeter (good quality digital or analogue)
Oscilloscope (30–50 MHz dual beam)
Logic pulser
Logic probe
Selection of leads and connectors
Resistance decade box up to 1 Megaohm
Capacitor decade box up to 10 Microfarads
Millivolt source
Regulated variable d.c. power supply (preferable +ve and -ve rails)
8 KVA variable auto-transformer
Current probe as accessory to multimeter - 150A range

GENERAL DISCUSSION ON REPAIR AND MAINTENANCE OF SCIENTIFIC EQUIPMENT

Discussant Panel:	R.O Aba	–	Nigeria
	M. Gardos	–	IAEA, Austria
	H. Elakkad	–	JEOL, Egypt

Aba, *Nigeria*: A survey done in Nigeria shows that there is equipment breakdown of 70% caused by misuse as opposed to 50% in Morocco. There is a need for (i) user training on-site; (ii) control over laboratory equipment; and (iii) sponsors to step-up aid for training in Africa.

We also need to consider effects of environment on equipment and effects of erratic mains supplies and variations in power supplies.

Staff movement is a serious problem in the Nigerian experience. Another problem is the wide range of equipment in use and the attendant problems on repair and maintenance.

Ambani, *Kenya*: The tendering methods for repair and maintenance in Government institutions is rather lengthy and technical staff have no control on the contractor selection. Incompetent contractors end up destroying a number of equipment. Also, delays in payment after the repair job has been done by contractors discourages competent firms. Contracts with local agents are needed.

Mzengeza, *Zimbabwe*: I see the major problems as being the lack of technical expertise available in Africa, and the lack of spares due to lack of foreign exchange. Other problems are the low budgetary provision for repair and maintenance and the lack of a replacement programme for equipment.

Oguntoyinbo, *Nigeria*: There is a need to consider the security of equipment — there is too much pilferage. There is also the need to consider the equipment lifetime and allow for depreciation in the budget.

Ngundam, *Cameroon*: With respect to the prevailing hostile environment — Africans lack initiative in averting the problem. Training policies must include environmental influences on equipment installation and siting.

Barankewitz, *Sartorious, Germany*: In the case of Africa there are no practical skills, just theoretical experience. An Instrumentation Centre should be a learning centre, providing maintenance technicians with analytical ways of trouble shooting, and using videos for training. There is a need to recruit and motivate service personnel. Training manuals do not replace practical knowledge. Technicians need to work together with local manufacturing agencies.

Gardos, IAEA, *Vienna*: The problems on repair and maintenance in Africa can be classified as objective and subjective. Among the objective factors are the absence of documentation, and the lack of spare parts. The solution to these problems is through networking, centralised documentation and spare parts supply. The subjective factors include lack of motivation, e.g., engineers are paid less than scientists. Engineers should get some percentage commission from extended service charges. Training, should be carried out continuously. R & D should be allowed to provide better motivation to service personnel. One need not worry too much about staff movement.

Lobo, *Kenya*: There is a need to build strong relationships of reliable counterparts between scientists and engineers. Scientists need to have confidence in the ability of the technician to repair his/her equipment. The maintenance schemes available must be utilised, e.g., IAEA are experts in service, spare parts, training, and equipment assistance. All of these are based on a computerised inventory.

Okaka, *Kenya*: With respect to the paper presented by Mr. Manyala, we have experiences with clients and centres — 292 firms. There can be an initial mistrust, and equipment brought for calibration may need both repair and calibration. There are also problems with payment.

Barankewitz, *Germany*: I have a question for Mr. Manyala: who is served by the KBS and what standards are used?

Answer: Anybody with equipment. The standards used must be traceable to International Standards, *via* a capable firm.

Gurkok, *Vienna*: Mr. Manyala, how effective is the instrument repair facility?

Answer: The repair and servicing is done by four engineers, and six technicians. We have facilities for the repair of KBS's own equipment, but limited capability for external equipment.

Okoyo, *Kenya*: ICIPE/ILRAD have achieved a computerised inventory, so why not have computerised maintenance for such activities as

- preparation of maintenance schedules and early equipment warnings;
- logging of equipment failures (analysing failure causes, determining spare stock levels, etc.);
- maintaining a knowledge base of experienced engineers and technicians?

Taylor, *Vienna*: There are available software packages developed by IAEA to aid in maintenance, e.g., CMPM (on dbase III) and MINT (commercial software, approx. US$700).

Gurkok, *Vienna*: There is also available a computer-aided instruction video — an interactive package available at UNIDO. Artificial Intelligence (AI) and Expert System, a way to transfer knowledge, can be used as a trouble-shooting aid.

Elakkad, *Egypt*: Some problems on repair and maintenance are caused by customers, e.g., some equipment is too complex, even with the availability of manuals. Customers spoil such equipment. Engineers of the wrong academic quality and having a generally poor background may be sent for training, achieving little. There is also a disrespect for machines, with trial and error repair. Users may forget about equipment overhauls, which should be done by a factory engineer.

Namukolo, *Zambia*: The high bills incurred by bringing in factory engineers can be offset by preventive maintenance which ensures longer periods between such service calls.

Jagne, *Gambia*: In the Gambian experience where there is no major institution of learning for back-up services, equipment is sent back to the manufacturers for repairs, hence the need for networking. Networking will help to ensure cooperation with neighbouring countries.

Kwankam, *Cameroon*: Maintenance should be coupled with management of equipment, i.e., Management and Maintenance of Equipment. We must exploit all the advanced technology on repair and maintenance.

Lung'wecha, *Tanzania*: To alleviate repair and maintenance problems, African countries should encourage science study at all school levels — this will generate in innovative citizens the necessary equipment maintenance culture.

Otieno, *Kenya*: With respect to new equipment and training — the training periods are always too short for the expected results. Hospital equipment users (doctors and assistants) are frequently rotated, resulting in equipment misuse.

Zinyemba, *Kenya*: On electronic modular repair — fault-finding is usually possible only up to the modules. Circuit information on modules is usually not supplied by a number of manufacturers. It is very expensive to replace a whole module. Some manufacturers are reluctant to provide details on certain equipment.

Kapkirwok, *Kenya*: There should be a cost/benefit approach to equipment maintenance, considering the cost of spares stocking *versus* the cost of disruption (with realities of constraints in Africa). About the question of obsolescence leading to the short life of equipment — is it possible to upgrade such equipment?.

Ngundam, *Cameroon*: Instrumentation Centres should look into the possibilities of manufacturing some basic equipment.

Oyuga, *Kenya*: Package or electronic card development and production could end up being more expensive. The deteriorating quality of products made in Kenya could be due to lack of inputs (foreign exchange problems).

Lobo, *Kenya*: UNIDO is preparing a paper on the issue of safety of service personnel with regard to environmental effects such as radio frequencies, PCB fabrication fumes, ultraviolet radiation.

Oguntoyinbo, *Nigeria*: Networking is necessary but self-evaluation is even more important, although at present it is being carried out in only a few and well-equipped countries. Centres should provide career guidelines, with each centre having its own strong areas.

CHAIRMAN'S SUMMARY

- Maintenance activities should be managed. They should cover all aspects including purchasing, training personnel, and securing documentation at the outset of purchase.
- Costing and budgeting of maintenance activities should be done.
- Motivation of maintenance staff is important.
- Depreciation of equipment must be taken into account.
- Calibration is a must to R&D activity.
- Safety and other environmental issues should be considered.
- Use of computer techniques and artificial intelligence should be encouraged.
- Hostile environmental conditions must be taken into account in equipment specification and be incorporated into user training.
- Problems of surges in ac supplies should be addressed.

SESSION III

DESIGN, DEVELOPMENT AND MODIFICATION OF SCIENTIFIC EQUIPMENT

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THE NEED FOR DESIGN AND DEVELOPMENT IN AFRICA

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Introduction

Design is taken to mean all that process of conceptual thinking, invention, visualisation, calculation, marshalling, refinement and specifying of details which determines the form of an industrial product. Engineering design is an interactive decision-making activity to produce the plans by which resources are converted, preferably optimally, into systems and devices to meet human needs.

The needs can be achieved if designers are exposed to the available gamut of experience in materials, hardware, software, packaging, thermal design, reliability analysis, product producibility and marketing considerations.

In the light of new technologies, software programmes have been designed to assume the role of fault-diagnosis technicians. A computer with a diagnostic programme can be instructed to invoke signals which can start tracing a fault within a given system or equipment. This fault, when located, is then displayed on the associated visual display unit(VDU). This scenario enhances the speed at which an equipment is put back into service, hence providing a high degree of availability of servicing. It is therefore important that African designers are effectively involved in both software and hardware design to capture this rapidly expanding area.

In Africa, like in any other part of the world, design and development rests on two major stems, namely socio-economic and ecological.

Socio-economic Factors in Equipment Design

A key characteristic of industrial design is a manufacturing context for which the designs are created. Industrial products are elements of material culture; they must communicate a strong sense of identity, and be tangible expressions of individuals and their social values. This means that objects cannot be studied simply because of their visual characteristics and qualities or as ends in themselves. Instead, the visual analysis needs to be supplemented by questions exploring wider areas. Industrial design involves two basic dimensions:

- How did the artifacts come into existence?
- Who designed what, when, how and why?

The answers to these questions are obviously vital in establishing the basic facts and understanding about the activity of design. The foregoing dimensions will also help us to identify our human talents and store our achievements for future development.

The scope of "design" in Africa is intended to help prospective and current designers cope with transient technology. Before starting to advocate a design culture within Africa, we need to address the following questions:

- What is the scope of the design market in Africa and beyond and how did it grow to its current size?
- What has been the role of venture capital in this field?
- What has been the role of entrepreneurship?
- What are the high-growth application areas and forces giving this growth? What growths are expected in different market segments?
- How will the market of the locally designed engineering product change over time and how will it continue to change?
- What are the new developments likely to reshape the market?
- Where can we go for more information?

In Africa there is a dire need to arrest the outflow of our talent that cross the seas to the developed countries for better job satisfaction and financial remuneration. Human resources are the most valuable asset on earth, therefore, there is a need for maximum utilisation and further development of engineers and scientists who have been amicably trained by the developed world. The drain of the meager foreign exchange earnings could in this way be easily arrested. In other words, instead of importing both human and material resources from developed countries to come and commission an optimum electronic system, we could design or develop a sub-optimum system that can meet the local need.

Environmental Factors in Equipment Design

Ecologically, Africa is situated in a very hostile environment with respect to high temperature, moisture and dust. Temperature is one of the environmental factors that contributes in a high degree to equipment failure. Therefore, it is most urgent for Africa to vigorously embark on the design and development of electronic sub-systems to be incorporated into the existing electronic equipment to reduce erratic temperature increases within the electronic signal-carrying components. Thermocouples, thermistors and any other suitable temperature-sensitive devices need to be explicitly examined, drafted and carefully designed or developed.

Most roads in Africa that traverse the factories or research centres that house sophisticated measuring instruments are rough and dusty. This factor accelerates the wear and tear of the electrical insulation of the device and consequently reduces the system reliability, hence leading to increased cost of maintenance. Most of the computer or microprocessor-based systems installed in Africa are adversely affected due to these harsh environmental conditions. This problem poses a big challenge for designers within the African region to develop an electronic system that will reduce the failure rate caused by dust.

Moisture is yet another environmental factor which require special design and development for Africa. Moisture causes corrosion and formation of water paths on the surface of electronic devices, which in turn interfere with the electrical characteristics of the equipment. Designs unique to this environment could enhance the reliability of equipment.

Conclusion

It is an opportune time for African scientists and engineers to conceive of the idea of collectively setting up regional design establishments. I would suggest that we involve the developed world and international organisations for funding and training once we have set up these centres. Initially setting up such an entity in Africa may look costly when seeking an optimal product. But, the product will earn Africa a name that reflects not only on our cultural setting but also propels a positive socio-economic impact.

References

Collins M. and Papadakis A. *Post-Modern Design*, Academy Editions, London.

Conway, Hazel. *Design History*, The University Press, Cambridge.

Teicholz, Eric. *Computer Aided Design and Manufacture*, Graphic Systems Inc., Massachusetts.

DESIGN, DEVELOPMENT AND MODIFICATION OF SCIENTIFIC EQUIPMENT: THE ZAMBIAN EXPERIENCE

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Introduction

In the Third World, the importance of design, development and modification of scientific equipment is just slowly being realised. The emphasis has been and is still on repair and maintenance. Indeed, there is a large stock of scientific equipment which is not working in Africa today due to poor maintenance, lack of skilled technicians, poor organisation in workshops, etc. The objective of this paper is to discuss the need for the correct design, development and modification of scientific equipment. Specific reference will be made to a recent design done of an instrument, a biological thermoregulator control unit and a modification done to the power supply of a gamma irradiator. The biological thermoregulator was requested by the Food Technology Research Unit and the modification was requested by the Radioisotopes Research Unit of the NCSR.

Statement of the Problem

There was an urgent need by the Food Technology Research Unit to store bacterial culture at a specific temperature. Meanwhile, the cooled incubators supplied were not working due to an omission of an essential component of the whole system. The system could not be modified. At the Radioisotopes Research Unit, the gamma irradiator kept blowing off one section of its power supply; repeated repairs were made but the problem persisted. There were several factors which caused this problem and the only solution was to build a more robust power supply, but flexible enough to be able to automatically cut off when adverse conditions prevailed.

Specification Development

Figure 1 shows a general block diagram of an instrument. Any scientific instrument or piece of equipment is essentially comprised of electronic circuits and other physical features which form a system. During operation, this arrangement of physical components works by sensing the inputs and processing them to produce outputs which can then be used to command, direct, regulate or give information about the nature of the inputs. When developing an instrument, therefore, there are several important factors which must be considered and these form the body of specifications.

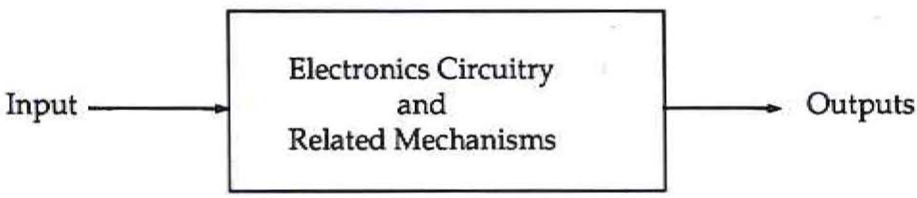

Figure 1. *System Block Diagram of an Instrument*

In designing the biological thermoregulator it was necessary to sit together with the requesting scientist and take notes about his requirements:

- To modify an ordinary domestic refrigerator to a temperature-presettable incubator.
- This incubator should operate in the range of 0–20°C.
- The instrumental error in temperature reading should not exceed ± 1°C.
- The instrument should display both the preset temperature and the internal temperature.
- The instrument should be adaptive, i.e. stand alone.

The instrument was designed from the above specifications. Other general instrument specifications which apply to most scientific instruments are:

Common mode voltage
Temperature range
Humidity range
Power Consumption
Size
Weight

Design Literature

In a design environment, it is essential to be familiar with the latest technological trends. Copious information is put out in journals and magazines. These provide the designer with up-to-date trends in instrument design and give him ideas about how specific and general approaches to design are tackled, what is new in the integrated circuit industry, and what instruments are new, etc. There is always a reader information card at the back of such magazines. The reader can circle the numbers corresponding to advertisements he is interested in and receive more information.

MAGAZINES

Some examples of important magazines are:

General: *Electronics, EDN, Electronic Design, Electronic News, Spectrum (IEEE).*

Communication: *Microwave Journal, Telecommunication, Microwave System News.*

Computing: *Computer Design, Digital Design, Mini-micro System.*

Instrumentation: *Industrial Research and Development, Instrument and Apparatus News, Measurement and Control News.*

Manufacturing: *Circuit Manufacturing, Electronics Test, Insulation Circuits.*

Optics: *Electro-Optical Systems Design, Laser Focus, Optical Spectra.*

DATA AND REFERENCE BOOKS

Data and reference books are probably the most important tools for the electronic designer. The reference books are written by the manufacturers of semiconductors and describe in very organised fashion their products.

These products are further organised according to their functions, e.g., transistors, memory, optoelectronics, power semiconductors, etc. For example consider a part with IC number DM8095 7410NS. In order to know what this is, it is necessary to find a master list of IC prefixes, suffixes and number series. On checking, this IC will be found to be a National Semiconductor chip 8095, hex three-state TTL buffer manufactured in the 10th week of 1974. DM is a prefix for National Semiconductor. The prefix in front of the IC number is a distinctive notation of the manufacturer. In this case DM indicates "digital monolithic".

IC manufacturer identifications: Some examples are

Prefix	**Manufacturer**
AD	Analog Device
AM	Advanced Micro Devices (AMD)
HA	Harris

Linear Generic Number Series are defined as follows: n means a digit, x means a letter, and () means an optional digit or letter. For example,

AD5nns	Analog Device
HA2nnn	Harris
LM	National Semiconductor

Digital Generic Number Series include

74nn (n)	National High Speed TTL
8nnn	National TTL
34nnn	Motorola CMOS

Suffix letters indicate package type and temperature range, e.g.,

Military temperature range	(–55°C to 125°C)
Industrial	(–25°C to 85°C)
Commercial	(0°C to 70°C)

Date Codes: There are four digits giving date of manufacture.

Data sheets also give component specifications and their electrical characteristics. Many times they also contain typical applications circuits. These should be carefully considered when selecting components for the type of application.

Circuit and Systems Design and Development

In most cases, a piece of equipment comprises of several circuits which make up the system. The actual design of an instrument is derived from the description of what needs to be done. Several steps are described below.

Algorithm Statement Approach (Conceptualisation): In this step a sequence of logical steps of what the instrument is supposed to do is coded. The approach considers input signals and conditioning, processing of the signal, finally to control or display.

Block diagram approach: Secondly a block diagram of the whole system is drawn with each block representing a specialised circuit function.

Circuit design: Next the circuits are designed, considering the overall specifications of the system. Choice of parts to be used is made here.

Prototyping: A good practice in design is to test the designed circuits individually and as a system before committing them to their permanent form. Different methods used for this are breadboards, PC prototyping boards, wire-wrap panels, etc.

PC board fabrication: The most reliable circuits are those fabricated on PC boards. After the system has been tested, it should be fabricated on the PC board. Care must be taken in designing the layout, which should meet the requirements. Some aspects to consider are connections to the boards, sockets of required current capacity, speeds, frequency effects, etc.

Housing of the circuit boards in an instrument: Circuit cards must be enclosed and connected to power supplies, panel controls and connectors. When housing circuits, an important aspect to consider in the overall system is cooling.

Figure 2 shows the block approach illustration of the Biological Thermoregulator and Figure 3 shows the Transducer Signal Conditional Circuit.

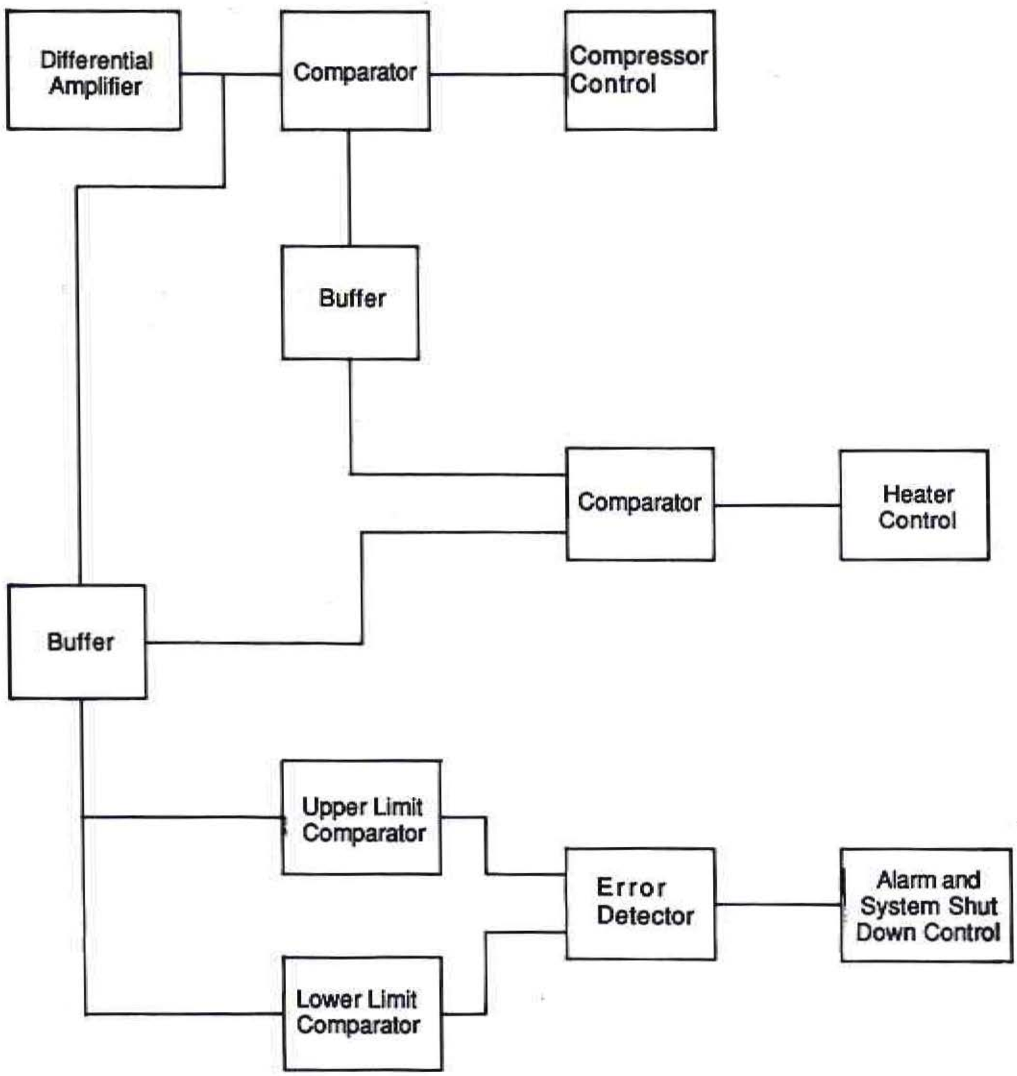

Figure 2. *Cooled Incubator Block Diagram*

Component Stock

Obtaining the necessary parts for a piece of designed electronic equipment can be difficult. For organisations and research institutions, it is always advisable to buy in bulk and stock up on the most commonly applied and used components. These should be stocked in the storerooms and stock levels replenished from time-to-time. A careful system of issuing parts should also be established.

Physical Facilities and Tools

For low-level design and development workshops, repair and maintenance workshops could be shared. However, for large-scale production, separate facilities are required. The major infrastructure required include the darkroom, drawing and drafting room, testing rooms, assembly rooms, mechanical workshops for mechanical fabrication, etc.

TOOLS

The major tools required in the design and development are:

> *personal computers, application software (CAD), PC boards, oscilloscopes, cameras, film processing facilities, chemicals for film processing, box-making tools, long nose pliers, snippers, soldering iron, solder, IC inserter, lead bender, solvent dispenser, solder sucker, bread boards.*

The list is expandable as application increases.

Human Resources

Manpower requirements for a reasonable design workshop should at the least be comprised of:

Digital and logic designers (2)
Analog designers (2)
Technicians (4)
Mechanical technicians (2)

More personnel would be required with increased volume.

Equipment Modification Records

When equipment is modified, it is very important to keep these modification records for the people who will maintain the equipment later. If the piece of equipment has a service manual, the modification schematic should be attached to it and a book for these modifications should be maintained.

Reconditioning of Old or Used Equipment

Old and used equipment sometimes needs to be reconditioned and used in many workshops. In carrying out these repairs, often times the product has been discontinued by the suppliers. Sometimes the suppliers themselves have gone out of business. In such cases obtaining spare parts will obviously be a problem. The approach is, therefore, to fabricate as many spare parts as possible, i.e., in the mechanical workshops. If the change must be done in the electrical and electronic sections, complete understanding of the function of these parts must be attained before replacing them with modified circuitry.

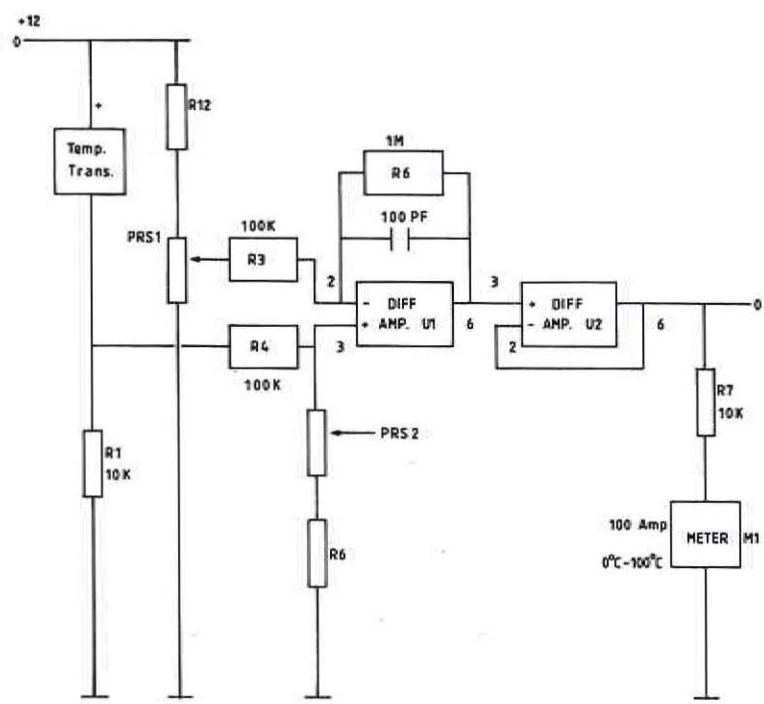

Figure 3. *Transducer Signal Condition Using a Differential Amptįier*

GENERAL DISCUSSION ON DESIGN, DEVELOPMENT AND MODIFICATION OF SCIENTIFIC EQUIPMENT

Discussant Panel:	G.S. Oyuga	–	KIRDI, Kenya
	J. Barankewitz	–	Sartorious, Germany

Nyambala, *Kenya*: What are the legal aspects of D&D, e.g., patenting of innovations?

Answer (Namukolo): Patenting is being considered for the nitrogen pump, for example.

Ambani, *Kenya*: What is the relative cost of local design inputs *versus* imported equipment?

Answer: Cheaper labour in Africa plus cheaper locally available materials means a cheaper product.

Kwankam, *Cameroon*: A lot of design work has been done in Africa but there is no institutionalised mechanism for translating the designs into products. We need to have product development centres alongside instrumentation centres, and to involve other engineering disciplines, such as chemical, materials, etc. The experience at ARCEDEM in Ibadan shows UNIDO is bent on promoting the development of basic technologies and not advanced technologies, especially electronic-based technologies.

Oyuga, *Kenya*: It is necessary to first acquire instruments to enable D&D to take place, although acquisition is a problem. There are also staff motivation problems which are in many cases inadequate. It is better to make simple discrete components, but there are also the problems of inadequacy of raw materials and physical facilities.

Barankewitz, *Germany*: The mass production objective should be borne in mind. Aim at modifying weak links in instruments like protectors, line filters, etc. This will involve talking to users. It is necessary to document your own prototype models. Consider interference areas in the design of equipment, e.g., electro-magnetic interference. Copy known instruments where necessary. It is advisable not to compete with professional suppliers and established manufacturers.

Ngundam, *Cameroon*: We need to aim at moving from D&D in design workshops to mass production units. This will require government assistance.

Mando, *Kenya*: The main thing is to develop a system of publishing new D&D ideas, which leads to the issue of establishing Instrumentation Centres and an effective networking of these.

Oguntoyinbo, *Nigeria*: There is a need for a national policy on research findings. Designs usually neglected in Africa find acceptance in the developed world. Instrumentation Centres should publish information on experiences, designs, etc,, in a periodical.

Lakhloufi, *Morocco*: Application of Specific Integrated Circuits (ASIC) can be designed and developed in Africa. We need to innovate, design and then fabricate.

Obasogie, *Nigeria*: Attention should be paid to solving existing problems which will build confidence in users and sponsors; hence the need to lay emphasis on modification and maintenance.

Okoyo, *Kenya*: Governments in Africa should stimulate entrepreneurship. There is a general lack of will to venture into manufacturing. Donors and donor agencies can help in sensitising governments on the need for manufacturing.

Gurkok, *Vienna*: In order to manufacture, the market for the manufactured goods must be identified — this is the biggest problem. Another problem in the Third World is the preference for imported items — the "imported item" syndrome.

Taylor, *Vienna*: The participants invited to this meeting should participate in designing systems to alleviate the damage commonly caused by power fluctuations.

CHAIRMAN'S SUMMARY

- R & M (repair and maintenance) must include D & D.
- Design for modification as well as design for new products requires government and donor support.
- Before deciding to manufacture equipment, think of markets for the manufactured goods and the problems of importation of components and other materials, e.g., plastics.
- African entrepreneurship is underdeveloped — it needs support.
- Sharing of information and experiences through networking is necessary.

SESSION IV

INSTRUMENTATION CENTRES

CHAIRMAN: P.O. Okaka

Director of Technical Training
Ministry of Technical Training and Applied Technology
Kenya

TRAINING IN THE MAINTENANCE AND CALIBRATION OF OPTICAL AND ELECTRONIC INSTRUMENTS AT THE RCSSMRS

L.Y. Zinyemba

Head of Engineering
Regional Centre for Services in
Surveying, Mapping and Remote Sensing (RCSSMRS)
Nairobi, Kenya

Introduction

The Regional Centre, as part of its main objectives, conducts training programmes for technicians and professionals from the member states of the Eastern and Southern African sub-region relating to the repair and maintenance of scientific instruments to assist them in gaining sufficient knowledge and practical skills to enable them to look after their own instruments.

Historically, almost all the countries in the sub-region have acquired a lot of scientific instruments over the years through either technical assistance projects, or direct purchase from individual western manufacturers. At the time of acquiring these instruments, the manufacturers were prepared to offer free regular after-sales services. Gradually this trend has changed and now most manufacturers are no longer interested in providing this essential service for free.

In addition, due to the rapid technological development that is facing both the manufacturers and the users, it is becoming increasingly difficult to maintain equipment which is five or more years old. As new equipment is introduced, the older generations are quickly phased-out by stopping both production of spare parts and the provision of technical expertise. Consequently, in many countries, either fairly new equipment operating within their useful lifetime are written-off for lack of competent local technical expertise or the necessary spare parts, or a lot of the scarce foreign exchange is spent on either sending the instruments abroad for repairs or bringing in overseas technical experts. Either way, the debilitating financial situation already prevalent in the sub-region is only made worse by such expenditures.

Training Courses Available

Having recognised these equipment maintenance problems, the Regional Centre (RCSSMRS), was initially established to cater for a limited range of instruments, specifically in the areas of surveying, mapping and remote sensing for the 22 countries of the Eastern and Southern African sub-region. Specialist training was provided to the selected staff of the Centre at the various equipment manufacturers in order to expose them to all aspects of maintenance of those instruments.

As both the demand for service in all the 22 countries and their respective numbers of equipment increased, the services offered by the Centre were found to be inadequate. This therefore required a totally new approach, wherein each country would provide the basic maintenance for its own equipment and the Centre would supplement such services by offering more specialised repair and calibration services. The Regional Centre was requested to develop training programmes which could be offered to the member states to enable them to reach the required level of competence in the basic care and maintenance of their own equipment. Two main areas identified for the purpose of designing the training courses are:

- optical/mechanical on-the-job training courses
- electronic-based maintenance courses

OPTICAL/MECHANICAL TRAINING COURSES

The optical/mechanical bench courses are designed for specific instruments such as microscopes of all types, theodolites, levels and photogrammetric plotters. The minimum duration of such a course is four weeks, depending on the level and prior experience of the trainee. A participant is taken through the dismantling of the whole instrument, the cleaning of all optical and mechanical moving parts, removing fungus where applicable,replacing worn-out parts, greasing all the moving parts, re-assembling the parts and calibrating the instrument for accuracy.

The Centre plans to develop these courses further during the coming four years by acquiring a wider variety of instruments on which training can be conducted. In this respect, the member states have been requested to identify the instruments of which they hold large stocks so as to enable the purchase of relevant equipment for training. So far since its inception, a total of 13 participants from the following countries have attended these courses: Kenya, Ethiopia, Uganda, Tanzania, Nigeria, Zambia and Botswana.

From our experience, it is quite clear that although member states are free to send their nationals to various factories for similar courses, the effectiveness has been far below expectation. This is mainly because factory training is specifically intended for those individuals with a wide range of experience in similar equipment from other manufacturers. Those with no such prior training/experience will therefore, find it extremely difficult to apply the ideas outside the factory environment. Also, the costs involved are way beyond what each member state can afford.

ELECTRONIC TRAINING COURSES

The nature and methodology used to repair and calibrate electronic instruments is completely different from the optical/mechanical courses described above. It is essential for trainees to have an in-depth understanding of electronics before they can be expected to logically identify and correct electronic faults in equipment.

A pilot study was conducted in the following countries in 1974 in order to determine the general level of experience of technicians/professionals in this field and their capability to repair and calibrate electronic instruments: Kenya, Uganda, Tanzania, Malawi, Zambia, Swaziland, Lesotho and Botswana. The results showed that there was an insufficient understanding of the applications of electronic devices. This lack of knowledge made it very difficult to logically approach a faulty electronic equipment with a view to identifying and correcting the malfunction.

Based on this study, a practical course on the application of digital electronics was designed and first offered in 1985. As more organisations have become aware of the course, the demand has risen beyond expectation. The six training units that were purchased at that time are insufficient to meet the current demand and plans are under way to double the number of units in the next year or so.

This course is designed either for technicians with a lot of practical experience in electronics or for graduates. Experience has shown that the graduates, though theoretically more knowledgeable than the technicians, lack practical exposure. The course has therefore over the years trained a mixture of these two cadres constituting a total of over 250 participants from the whole sub-region.

In 1987, a microprocessor engineering course was introduced, again based on requests from the member states of the sub-region, since most modern equipment now incorporates microprocessors. The course was designed with emphasis on the applications of microprocessors in industry. The participants are expected to understand the interface devices that function alongside the microprocessors, the details of the microprocessor internal architecture, and the application of these as tools for particular functions. In order to achieve the last objective, the participants are taught how to write assembly language programmes which perform specific tasks, like the driving of a motor at specified speeds, the control of traffic lights, the control of oven temperatures, etc.

This course is becoming just as popular as the digital course, and so far 150 participants from the sub-region have attended. At this rate of increasing demand, we plan to double the number of training computer units in the near future.

Overall, these two electronics courses are helping technicians and professionals in the sub-region to develop logical approaches in the repair and calibration of their electronic equipment. Currently, the user organisations in the sub-region who have found these courses essential include Repair and Calibration Centres, Bureaus of Standards, the police, the army (including the airforce), telecommunications organisations, airlines, railways, heavy-industry-based manufacturers, etc.

Conclusions

Facilities are available at the Centre to conduct some courses in the area of repair and calibration of both electronic and optical/mechanical equipment. It is, however, necessary to increase both the quantities and types of the equipment in order to cope with the expressed increase in demand. These courses are currently being offered to the Eastern and Southern African sub-region, although other participants from outside the region are also accepted.

The details of these courses and the history of the Centre are available in Appendix I to this paper.

Appendix I

ESTABLISHMENT OF THE CENTRE

In response to Resolution 816 (xxx1) of the United Nations Economic and Social Council, the Secretary General of the United Nations convened the first United Nations Regional Cartographic Conference for Africa in 1963 in Nairobi, Kenya. The Conference recognised that surveying and mapping were important tools for natural resources inventory and exploration and urged the Executive Secretary of the Economic Commission for Africa to establish institutions capable of rendering to member states specialised services in surveying and mapping on a regional and sub-regional basis.

Following this resolution, a meeting of experts on joint centres for specialised services in surveying and mapping was held in Addis Ababa in 1965. At that meeting, the need for a Regional Centre was again emphasised and unanimous support was given to its establishment to meet the rapidly increasing demand of member states for services in surveying and mapping important for socio-economic development and in particular in planning for the exploitation of natural resources, for which Africa was known to have a great potential.

During the inter-governmental meeting held in Nairobi in 1974, representatives of member states of the Eastern and Southern African sub-region of the Economic Commission for Africa confirmed their support for the establishment of the Centre in Nairobi and signed the final act. At the same meeting, the Agreement concerning the establishment of a Regional Centre for Services in Surveying and Mapping was finalised and ratified.

GOVERNANCE OF THE CENTRE

Established under the aegis of the Economic Commission for Africa (ECA), the Centre has a Governance Council, the Chairman of which is the Executive Secretary of the United Nations Economic Commission for Africa. The Governing Council is assisted in technical matters by the Technical Committee. The Centre has a Director General who is responsible for the day-to-day running of the Centre under the general guidance of the Council. The Governing Council is composed of at least one member from each of the contracting parties, with the Director General as an *ex-officio* member and its Secretary.

The Technical Committee consists of all Directors of Surveys of the Contracting Parties, the Director General and Heads of Departments at the Centre. This Committee advises the Council on all technical matters affecting the Centre's services.

CATCHMENT AREA OF THE CENTRE

The Centre was established to provide specialised services to 21 countries in the Eastern and Souther African sub-region as a first step, with plans to cover the whole of the African Region when fully established. Thus, the Centre's present "catchment" area includes Angola, Botswana, Burundi, Comoros, Djibouti, Ethiopia, Kenya, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Seychelles, Rwanda, Somalia, Swaziland, Sudan, Tanzania, Uganda, Zambia and Zimbabwe.

To become a signatory member state, a country must sign the Agreement establishing the Centre. Thus, out of 21 participating member states, 12 have signed the Agreement, namely, Kenya, Uganda, Tanzania, Malawi, Somalia, Comoros, Lesotho, Swaziland, Zambia, Sudan, Ethiopia and Botswana. In all, the Centre serves a sub-region with a total population of about 150 million in an area totalling 10.8 million square kilometers.

ENGINEERING COURSES OFFERED BY THE CENTRE

The following are descriptions of courses offered in 1990.

El Digital Electronics

Objectives:	To acquaint engineers and technicians with up-to-date knowledge and skills in the practical applications of the rapidly developing field of micro-electronics and digital electronics technology.
Duration:	Five weeks/offered three times yearly.
Venue:	Regional Centre for Services in Surveying, Mapping and Remote Sensing, Nairobi.
Entry Requirements:	Degree in Electrical/Mechanical Engineering or H.N.D. in Electrical/Electronic Engineering or Part II Certificate in Electronics/ Telecommunications or Equivalent.

Fees: US$ 3,250 inclusive of hotel with full board, tuition and transport between hotel and Centre.

Course Contents: Number systems and codes, binary arithmetic, logic circuits, Boolean algebra and minimisation, combination logic circuits, gate level combination, logic design, digital logic families and their characteristics, MSI combination circuits (decoders, multiplexers, decoders and multiplexers as universal logic elements). Magnitude comparators, parity generators/ checkers. Arithmetic elements (ALU, PLA's and ROM's). Sequential logic circuits (RS, DFF, switch debouncing, clocked FF/JKFF, counters/ dividers, counter design, design of sequential timing circuit shift registers/UART's). Monostables/Pulse generators. Analogue/Digital circuits: General purpose operational amplifier. Comparators, timers. D/ A conversions. A/D conversion. BUS and line driving. VCO and PLL and their applications. Interfacing circuits. Opto switch. Hall switch/ Flow meter applications, power drivers, stepper motors and shaft encoders. Memories: ROM, EPROM, EPPROM, EEPROM, static RAM, dynamic RAM, magnetic bubble memories, magnetic disk, floppy diskettes, CCD memories and cassette tape storage. Digital computer, memory address, data reading and writing, Central Processing Unit. Input/Output interfacing, RS 232C, handshake and interrupt. Microprocessor element 8085, 8086/8088. Introduction to computer languages: High level, assembly and machine languages.

E2 Microprocessor Engineering

Objectives: To acquaint engineers/technicians with up-to-date knowledge and practical applications of 8-bit and 16-bit microprocessors of industrial concern.

Duration: 6 weeks/offered three times yearly.

Venue:	Regional Centre for Services in Surveying, Mapping and Remote Sensing, Nairobi.
Language:	English.
Entry Requirements:	Digital Electronics Course (conducted at the Centre) or its equivalent or degree in Electronic Engineering with experience on 8-bit and 16-bit microprocessors.
Fees:	US$ 3,720 inclusive of hotel with full board, tuition and transport between hotel and Centre.
Sponsorship:	Employer or Donor.
Course Content:	Decoders/demultiplexers, multiplexers, magnitude comparators, arithmetic logic unit (ALU), shift registers/UARTS, D/A, A/D conversion, open collector gates, Tristate and BUS techniques, review of semiconductor memories: RAM, ROM, PROM, and EPROM, introduction to computers, programming in BASIC, general aspects of microprocessors, 8086/8088 microprocessor-based system, support chips for 8086/8088, input, output operations, microcomputer programming, input/output interface.

E3 Maintenance of Optical Surveying Instruments

Objectives:	Tailor-made to train technicians and professionals how to detect simple faults and early fungus growth, and to carry out simple care and maintenance of survey instruments.
Duration:	3 months = A + B + C. Offered twice yearly.
Venue:	Regional Centre for Services in Surveying, Mapping and Remote Sensing, Nairobi.
Fees:	Tuition fees at US$ 1,200 per month.
Language:	English.

Sponsorship:	Employer or Donor

E3 A: LEVEL ONE (4 weeks)

Entry Requirements:	Good knowledge of mechanics, craft practice. Good knowledge of technical drawing. Good eyesight.
Course Content:	Basic principles of levels and theodolites. Theory on care and maintenance of optical survey instruments. Identification of faults, damages, fungus and optical distortion in the instruments.

E3 B: LEVEL TWO (4 weeks)

Entry Requirements:	Level one above or technicians/professionals with experience in surveying/mapping/ mining/ or civil engineering (construction).
Course Content:	Dismantling a level. Cleaning of all parts. Repairing mechanical parts. Greasing. Re-setting of optics, centering of circles. Re-setting of compensators and collimators adjustments. Complete overhaul of theodolite. Adjustments of the theodolite for horizontal and vertical collimators, tilting axis and optical plumet.

E3 C: LEVEL THREE (4 weeks)

Entry Requirements:	Level one and two above or technicians/ professionals with some experience in cartography, photogrammetry or photomapping.
Course Content:	Basic principles of construction and operation of photogrammetry instruments. Care and maintenance of photogrammetry instruments. Fault detection. Dismantling of a plotter with its associated table. Cleaning, greasing, oiling and re-assembling. Calibration of the instruments.

For further information, please contact:

The Director General
RCSSMRS
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ESTABLISHMENT OF INSTRUMENTATION CENTRES

P. Mandalazi

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Introduction

The application of modern scientific instruments and equipment in chemical analysis and other branches of science has produced significant success in research and development throughout the world. Despite the advantages posed by instrumental methods, their widespread adoption can only be realised with proper use and the availability of adequate maintenance and servicing of the relevant equipment. Africa, which depends on maintenance engineers from overseas, is often denied the advantages of modern instrumental methods, mainly because of the shortage of maintenance engineers on the continent.

A significant amount of scientific equipment is continuously provided by governmental and non-governmental agencies, to laboratories located where there is little or no access to repair and maintenance services from manufacturers or suppliers. Furthermore, in such places it is difficult to find private enterprises or institutions which can offer qualified advice or services to maintain and repair the equipment. No laboratory work, be it research, quality control, medical testing or industrial development, can succeed without properly functioning equipment.

The dependence of research and development work on complex and expensive instrumentation is immense. The effect of this dependence has been to inhibit the role of developing nations (especially African countries) in the advancement and exploitation of various technical achievements made in developed countries. It is therefore essential that the less fortunate laboratories try to find the means and assistance to take care of their equipment as far as is possible within the resources available locally and regionally.

It is hoped that through the scheme proposed by this Workshop, a wide spectrum of courses that would include laboratory management, instrumentation and many others, would be offered in Africa. This paper suggests the kind of technical background of resource personnel that would be required for such workshops and seminars.

NEED FOR REGIONAL INSTRUMENTATION TRAINING CENTRES

As mentioned before, one major reason for the technological gap between developed and developing countries is the lack of skilled technical personnel in developing countries to maintain and repair scientific instruments. The lack of basic maintenance skills on even simple instruments like digital balances make things even more difficult in laboratory work. The situation is made worse by the absence of proper diagnostic skills on faulty equipment; procurement of the correct spare parts then becomes a problem. A large proportion of the scientific instruments not in working order results from the lack of operational skills. To alleviate this situation, establishment of Instrumentation Centres in Africa should be given top priority.

Objectives of the Training Centre

In order for the proposed Instrumentation Centre to be viable, a wide spectrum of training facilities should be provided. The Training Centre will have to provide workshop facilities for technical staff for repair and maintenance of general laboratory equipment. Training of technicians in mechanics and electronics will have to be provided. The Training Centre should also be able to establish and organise a store for maintenance materials, tools and spare parts for the equipment used by laboratories in member countries. The Centre should also be able to assist in the procurement of new equipment. This will enable member states to have equipment of almost universal origin so as to make the procurement of spare parts easier.

The Training Centre will have to address its objectives within the following framework:

- general equipment and instrument technology and technical diagnosis;

- repair work for mechanical, optical, electrical, electronic and refrigeration units, mainly as on-the-job training;

- organisation of a preventive maintenance management and a maintenance workshop for national laboratories;

- organisation for the procurement of spare parts for member countries.

With respect to the above objectives, the general aim will be to create a good in-house service team which will be prepared to withdraw unusable equipment, diagnose faulty and defective instruments and repair equipment which can be restored easily and cheaply without a large expenditure.

Target Groups

Basically, three levels of training categories will be required:

ORGANISING AND ADMINISTRATION PERSONNEL

This group includes staff members and heads of scientific institutions. Included here are the financial controllers of such institutions, since these are the people who authorise purchases of instruments and equipment. As this group is mainly responsible for organising and managing scientific institutions, they include personnel in the following positions:

officers in charge of technical administration
laboratory leaders
administrative managers of technical institutions

This group will be expected, through seminars and workshops to (i) gain awareness and be able to understand the usefulness and value of scientific equipment and instruments, (ii) appreciate the problems resulting from having non-functional equipment in scientific work, and (iii) assist in the procurement of instruments and spare parts.

ADMINISTRATIVE MAINTENANCE PERSONNEL

This category includes technical administrators of national laboratories, workshops or maintenance units. These people will probably hold the following positions:

Chief technicians of laboratories
Heads of repair shops or maintenance units

This group will be expected to know how to handle and care for instruments, execute preventive maintenance measures and also communicate and cooperate with service and repair personnel in case of breakdowns. These people will also be expected to train laboratory technicians (through on-the-job training) in how to handle and operate laboratory equipment.

REPAIR AND MAINTENANCE TECHNICIANS

This target group will include the actual repair technicians, and it is the group that will be resorted to, in case of breakdown of instruments. The training programmes for this category of personnel will be oriented along the following directions:

mechanical and optical instruments
electrical and electronic devices
refrigeration units

This group will be exposed to full-time training programmes. After training, the group will have to communicate with instrument users about fault symptoms; make the correct diagnosis in case of breakdown; and repair, calibrate and test the equipment. They will also be expected to assist in the procurement of spare parts and planning of preventive maintenance.

Concept of the Training Programmes

CONTENT

The proposed content of the training courses should include, among other things, the following;

general diagnosis
cleaning and lubrication
repair techniques
proper use of documentation
calibration of instruments
procurement of spare parts

METHODS

It is proposed that the training programme will need to include the following:

lectures
practicals
on-the-job training
group work
seminars/workshops
simulations

LECTURING STAFF

For the whole programme to be effective, the teaching staff will have to be of high calibre, and hold qualifications relevant to the courses on offer. Basically, two categories of teaching staff will have to be available: permanent staff and guest experts. The guest lecturers will be experts sent by the manufacturers of scientific equipment.

ADMISSION AND COMPETENCE OF TRAINEES

Trainees will be recruited from young people holding good qualifications, at least a diploma from technical colleges or a degree in the natural sciences.

Access to Complex and Expensive Equipment

Internationally recognised laboratory work is becoming increasingly dependent upon sophisticated and expensive instrumentation and laboratory equipment. These items consequently occupy a growing proportion of the budgets of research institutions in the developing countries and elsewhere. If the work of developing-country institutions is to be presentable and respected internationally, their laboratories must have access to and be able to use the methodologies in use in the rest of the world.

To alleviate the economic constraints on purchasing of expensive equipment, it is hereby suggested that an Equipment Hiring and Rental Service for expensive instruments be established under the umbrella of the proposed Instrumentation Training Centres. By the same token, developing countries should be encouraged to establish centralised units for expensive equipment. In this way, one piece of an expensive equipment such as an electron microscope or GC-MS, etc., might suffice for all laboratories in a given country.

Conclusions

In view of the above discussion, it can be said that there is a need for the establishment of an Instrumentation Training Centre for training in the repair, servicing and maintenance of scientific equipment in Africa. Training in procurement procedures will also have to be given.

Training activities will need to emphasise aspects of preventive maintenance and laboratory management. Interlinking and sharing of competencies and experiences with regard to the use of research equipment will have to be promoted within Africa. Access to expensive equipment will have to be established either through the Equipment Hiring and Rental Services or National Centralised Units.

ESTABLISHMENT OF AN INSTRUMENTATION UNIT: A NIGERIAN EXPERIENCE

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Introduction

The Nigerian Institute For Oil Palm Research (NIFOR) is one of the 25 research institutes in Nigeria funded solely by the Government and it has the mandate for research on oil palm, coconut, raphia, date-palm and other palms of economic importance. For NIFOR to be able to actualise the above mandate, it has at its disposal the following laboratories and processing plants:

Plant Breeding Laboratory
Plant Pathology Laboratory
Plant Physiology Laboratory
Biochemistry Laboratory
Chemistry Laboratory
Computer Centre
Palm Oil Mill
Palm Wine Bottling Plant
Agronomy Laboratory
Internal Telecommunication System
Internal Electricity Generating Plant
Internal Water Pumping Station.

Each of the above laboratories is equipped with not less than 25 instruments/equipment and this ranges from basic laboratory apparatus such as hotplates, autoclaves, microscopes, pumps, sandbaths, ovens, waterbaths, pH-meters, furnaces, centrifuges to the more complex ones such as spectrophotometers, autoanalysers, etc. The power generating plant, water pumping station, oil mill and bottling plant are all fitted with electronic control instruments. NIFOR also has an internal telecommunication system to cater for its staff strength of about 2000, while the resident population is estimated at about 14500. The latter figure includes the dependants of NIFOR workers.

NIFOR, which was established 52 years ago, depended on equipment/instrument manufacturers' local representatives for the installation, maintenance and repair of its laboratory equipment and apparatus, internal telecommunication facilities and other similar services. The performance of some of these representatives was credible and some were not. As the years rolled by, the number of credible representatives reduced and this fact made NIFOR seriously consider in 1978 the need to have an Instrumentation Unit of its own.

The objective of NIFOR in setting up this Unit was to have staff of its own that would be in a position to advise management and perform the following:

- advise on the type and model of equipment/instruments to purchase;
- receive the equipment/instruments on delivery;
- participate in installation;
- ensure that all manufacturer's specifications are adhered to before commissioning.

Recruitment of Personnel

One of the major problems of equipment maintenance personnel has been that the Maintenance Chief would at best be a highly skilled mechanic, but without pretensions to any planning or organising experience. His status is therefore low in the hierarchial level and scheduled maintenance is either conspicuously ignored or is sacrificed for other immediate prevailing needs.

Hence, when the Nigerian Institute for Oil Palm Research decided to establish an Instrumentation Unit, great care was taken when recruitment was to be done. It is difficult to find someone adequately knowledgeable on specific analytical equipment to recruit; rather, what one almost always finds is someone with a basic background training in physics/electronics or electrical engineering who will then be given a dedicated training in the industry or made to attend courses organised by manufacturers on the maintenance of certain instruments/equipment. Based on this fact, advertisement was made in Nigerian newspapers asking for interested persons with a bias in physics/electronic laboratory techniques either at BSc or Higher National Diploma (HND) level with not less than five years working experience in a similar organisation. Persons employed were expected to undergo further dedicated training on instruments/equipment.

Subordinates with a basic background of not less than Ordinary National Diploma (OND) in relevant fields were later employed. An in-house training was later organised for these subordinates.

Technical Assessment Report

On assumption of duty, we took stock of NIFOR laboratory equipment, apparatus, telecommunication facilities, and control and monitoring devices at the plants listed above and then wrote a formal technical report to the Management. The technical report covered the following areas:

- Need for dedicated training on some highly specialised equipment/ instrument held by NIFOR.
- Provision of physical facilities.
- Support for technical and administrative staff and appropriate in-house training for them.
- Procurement of tools and measuring instruments for extensive work.

DEDICATED TRAINING

A list was made of the instruments and equipment which NIFOR had in use but with which we were not very conversant. We then wrote to the manufacturers to arrange for a maintenance training programme for us. We made it clear to them that the cost of the training would be shouldered by NIFOR. All of the manufacturers replied, opening the door for training for us. The training, which lasted for three months, took us to England and Switzerland and it was very gainful. This exercise also helped in further building up our confidence in the profession. The opportunity was also used to shop for additional tools and spares not available in Nigeria and when we eventually came back, we were reasonably equipped for the task ahead of us.

PHYSICAL FACILITIES

A sketch of an Instrumentation Unit was made and presented to management for implementation. The Unit covers a floor area of 7 x 14 m comprising a fault/request reception workshop, store, three offices, toilet, and washroom.

Before the Instrumentation Unit came on stream, NIFOR already had an Engineering Maintenance Department with facilities for the following: welding, fitter machinist, blacksmith and carpentry workshop. Hence there was no need to set up an identical section in the plan of the Instrumentation Unit presented. Transportation of men and materials and equipment/ instruments was also catered for by the existing Motor Transport Unit of NIFOR.

TEST EQUIPMENT AND TOOLS PROCURED

Test equipment procured included multimeters (universal meter) of at least 20KV, signal generator, multi-range power supply, oscilloscope, extratension (EHT) voltmeter.

Various sizes and types of screw-drivers, spanners (flat and box), shear and side cutters, hammers, hacksaws, soldering irons, solder suckers, files, etc., were purchased. Service aids such as cleaning fluids, adhesives, insulation tapes, air dusters and suckers, etc., were also procured.

Spare Parts Procurement

A maintenance management programme cannot succeed unless it is backed up with effective spare parts provisioning policies. When an equipment is ordered, spare parts, service manuals, electronic circuit diagrams and any other items which may need regular replacement should be included in the purchase order. Although some companies are reluctant to sell all these items, if it is stipulated on the order form that the equipment will not be accepted without them, the company will usually comply.

When spare parts arrive with new equipment, they are accepted into the store and indented specifically for that equipment. From experience, the correct minimum level of stock is usually determined.

Spare parts are ordered for the store annually from principal manufacturers overseas and Radio Spares of Great Britain. This supply is supplemented with what is locally available. In some cases, the Crown Agents of Great Britain are requested by telex to procure spare parts on behalf of the Institute. Recently, however, since it has become difficult to obtain foreign exchange, overseas purchasing has been drastically reduced. Hence when an equipment is received, a critical study of the schematic diagram is done with a view to identifying the most vital components, and then procuring some and locating where others can be obtained in the event of faults. These components or their substitutes have done the job quite satisfactorily.

Documentation and Record Keeping

Log books and history cards are designed and each equipment has these records attached to it. Log books, history cards, manuals, and schematic diagrams are carefully kept and where no schematic diagram arrives with the equipment, effort is made to keep a record of the electronic data (e.g., code number of components, wattage of motors and bulbs), because in the event of a fault, some of these components may burn out beyond recognition. The equipment is opened up and operated under a specific input condition. Note is made of the parameters obtained. Voltage measurements at certain test points within the equipment are taken and documented.

When an equipment is found to be faulty, the officer manning the equipment fills a standard form designed by the Instrumentation Unit and distributed to each Division (See Complaint/Request Form in Appendix I) and dispatches it to the Instrumentation Unit. On receipt of the complaint form, a job order is created for the equipment and the maintenance officer then calls for the history card of the equipment and the log book to know if a similar fault has been reported before. This helps to determine what spare part to take along and assists in trouble-shooting and saves time.

A job card as shown in Appendix II is then opened for the fault and after the repair, all materials and time spent on the job are entered on the job card so that it can be costed. Also, it is with this job sheet that a store requisition is raised to obtain materials from the store. The store requisition voucher has to be authorised by a fairly senior officer before the storekeeper can release any item.

Laboratory Management

There is always available adequate working space, fire extinguishing apparatus, and first aid items. Adequate information on safety and regular training by way of lectures or workshops on advantages of keeping to safety rules and work ethics are frequently offered.

Every employee is informed about activities going on in the Unit so that the sense of belonging and cooperation from all is sustained. Where chemicals are used, the containers are clearly labeled. On the work bench, an isolating transformer is installed for obvious reasons, as it is both a training and work bench.

From experience, it was discovered that one of the ways staff could be exposed further to repairs on modern and varied electronics was by accepting faulty domestic and industrial equipment from individuals and sister institutions. Self confidence in performing the repair is further developed through working on these sets and this in turn enhances confidence and experience in tackling the primary job, i.e., scientific instruments. Great care should be taken by the supervising officer, however, to see that this is not done at the expense of the primary assignment.

Seminars and Workshops

Any scientific instrumentation or equipment is a combination of both electronic and mechanical components which perform a particular function and for someone to be able to obtain the desired result, he/she needs to be aware of the principle of operation, and to be able to manipulate the equipment and recognise when it is not performing well. Faults are likely to be prevented if the user or operator is familiar with the operation of the equipment, hence seminars and workshops are organised periodically for laboratory staff on first-line maintenance approach; when new equipment is installed, a talk is given with emphasis on its new features or its dissimilarity to the old ones.

Modification and Adaptation

After about three years, it was observed that the Unit had fully overcome the initial take-off problems, and the desire to meet demands from the Research Division by way of improvisation encouraged the Unit to move into areas of Research and Development, with emphasis on equipment that would satisfy the immediate requirements of the on-going research programmes and utility exigencies.

The frequency of faults reported to us was very high for the first twelve months and this gradually reduced with time. The set of instruments that have so far continued to suffer faults are those fitted with electrical heating elements, and temperature control circuits or gadgets. To reduce the frequencies of faults in the series of equipment just mentioned, a look was taken at the problem areas with a view to modifying and adapting the equipment to our peculiar needs.

Design and Development

The humble design effort made by us in the course of adaptation and modification led further to the design of complete prototype units of basic laboratory instruments/equipment such as ovens, waterbaths, hotplates, sand and oil baths by us. Our colleagues in the Mechanical Engineering Unit of NIFOR assisted with the sheet metal work while we did the design and fabrication of the source of heat (i.e., element), temperature control circuit and fitting of switches, plugs, indicators, and finally painting and labelling of the complete equipment unit.

The instruments/equipment mentioned here have been put to use and the performance has been satisfactory, with some of them in operation since 1982. (*NIFOR News Letter*, June, 1982). It has not been possible so far to optimise this gain by way of mass producing what has been developed, partly because it did not fall within our primary mandate.

Conclusion

It will be seen from the report given in this paper, that setting up an Instrumentation Unit is not something that can be done overnight. It is a growth process that could grow into anything and we hold the view that no gainful growth should be stranded. Secondly, the volume of scientific instrumentation activities often handled in laboratories in Nigeria and perhaps in Africa over a given period seems inadequate to justify the rate at which individual institutions must acquire new equipment. To achieve cost-effectiveness, therefore, and to be up-to-date in instrumentation technology, one would like to recommend that certain centres or institutions with specialised equipment and personnel receive samples from sister institutions for analysis. In this way, the scarce resources which are characteristic of most African countries could then be invested in a few Centres which would then be able to operate at the highest world standard. This proposal will be feasible if Africa sees itself as one group of people having a common problem.

I am grateful to the ICIPE, the Government of Kenya and UNDP for organising this Workshop and for sponsoring me.

Appendix I

INSTRUMENT WORKSHOP

COMPLAINT/INSTALLATION FORM

Name of Department: ....

....

Name of Equipment/Instrument: ....

....

Job Required:...

....

Nature of Fault Observed: ....

....

Date First Noticed:...

Function-Research/Routine: ....

....

....

Name of Officer Manning Equipment:..

....

Officer Requesting: ....

....

....

Head of Division Signature

....

Date

Appendix II

INSTRUMENTATION UNIT

JOB SHEET

Job Sheet Number: .... **Date:** ....

Sites of Works: ....

Work Required: ....

....

Vote of Charge: ....

....

Date Commenced:............................**Date Completed** ....

User's Remarks: ....

....	....
Job certified by	**Head of Division Signature**
....	....
Job Collected by	**Materials Used**

ESTABLISHMENT AND NETWORKING OF INSTRUMENTATION CENTRES IN AFRICA

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Introduction

Research is fundamental to meaningful development in any sector of human endeavour. Equipment and instruments of varying sizes, make, shape and functions are the vehicles for research as well as for the transfer of technologies. In most African countries there are a number of international and regional research centres like IITA, ILCA, etc., with highly sophisticated equipment and instruments. There are also many governmental and non-governmental organisations dealing with equipment of different types for research and development. It is known that the adoption of scientific and technical information (STI) systems has proceeded much more slowly in Africa than in Asia and Latin America. Constraints include shortages of funds and trained personnel, the absence of an enabling environment and lack of native-language software and of peripherals for acquired hardware.

A survey of the equipment and instruments available at the local research stations would show that many are obsolete; others have either broken down as a result of lack of routine servicing, maintenance and repair. The main reasons are the deficient "maintenance culture" or lack of it completely, poorly trained personnel, and lack of spare parts. In these days of technological superlatives and the rapid rate of introduction of new technologies, most of the technologists and maintenance engineers have not had the opportunity of seeing particular equipment during their training period, let alone operating or repairing them. Furthermore, with the dwindling financial resource base of most African nations, there are few opportunities for training and re-training of personnel on-the-job as was the situation many years back.

Equipment Technology and Development

Research and development is fast becoming highly technical and sophisticated. The knowledge acquired, as well as the equipment for the acquisition and transfer of such knowledge, is equally becoming more complex on a day-to-day basis. Manufacturers of this equipment are always in the hot race to beat other manufacturers at the game.

The different areas of scientific specialisation such as agriculture, soil science, energy and power, medicine, information, data systems and documentation, electronics, etc., all require specialised equipment for their research. The need for highly competent personnel for the maintenance, repair and servicing of such equipment cannot be over-emphasised. There is a fundamental relationship between the type of equipment, the functions they are to perform, the ecological zone and the basic climatic belt in which they are to be used. For example, the machinery needed on a particular farm depends on the type of farming, the soil and climate, and on the size of the farm. However, the value of individual machines depends very much on the source of power used for working them, availability of spare parts and competent personnel to operate service and maintain such machinery. The socio-economic development of the nation should also be considered. As population increases, so does pressure for intensification of agriculture and research into various other fields. Intensification is always associated with greater requirements for labour or power or both. These in turn lead to an increased requirement for better and more efficient equipment and instruments.

With the ever-increasing rural population of most African nations and the need to catch up with modern-day technologies, research and development, it is absolutely necessary to have Centres all over Africa where the most recent equipment would be available. These Centres would also serve for the training and re-training of personnel for competence in different areas of scientific inventions.

Suggested Zones for Instrumentation Centres in Africa

Most African countries come under the "developing" category, in which case there is a wide variety of levels of development. The rate of development is further complicated by many other socio-economic, cultural, geopolitical and physical factors, as well as the size of the continent. Focusing on Africa and trying to implement policies is tackling the problems of a really complex conglomerate. However, the first decision in any process is to arrive at a set of objectives; and in our case that decision has been taken, i.e., to set up Centres for Advanced Training in the Repair, Servicing and Maintenance of Scientific Instruments and Equipment. In pursuance of this objective for Africa, I would like to suggest for a start the establishment of five(5) major Centres from four zones:

North Africa (The Sahara zone)	1 Centre
East and Central Africa	1 Centre
West Africa (Humid tropical zone)	2 Centres
Anglophone	1 Centre
Francophone	1 Centre
Southern Africa	1 Centre

Each of these Centres could have sub-centres depending mainly upon the availability of funds, personnel and equipment to execute the programme.

Factors for Consideration in Locating Proposed Instrumentation Centres

A number of factors, among others, should be considered when deciding on the specific countries where the Centres should be located. These are outlined below.

LEVEL OF POLITICAL STABILITY AND SOCIO-ECONOMIC SET-UP

For any meaningful development and academic advancement, there is the need for political stability. One of the primary considerations for the location of a Centre in a country is the degree of stability. It may be argued that political stability cannot be one hundred percent guaranteed anywhere and that there could be political eruptions or turbulence at any time, but the fact remains that over the years, some nations have enjoyed a relative measure of "peace".

The socio-economic climate of the nations should also be considered. What levels of trade are maintained with the international community? Are there trade restrictions that might later hinder the movement of equipment and instruments to neighbouring countries?

NATIONAL POPULATION, INSTITUTIONAL INFRASTRUCTURE AND LEVEL OF DEVELOPMENT

The national population, number of institutions of higher learning and research institutes, as well as the general level of development, should be considered. The immediate community, i.e., the populace, would among other things provide some level of technical personnel for the management and operations of the Centres. The institutions of learning and research would make use of the equipment and instruments. Depending also on the level of development and the population size, people should be able to borrow or lease the equipment. The level of development would dictate the number of large-scale operations going on in the country, which would in turn determine the rate at which the private and non-governmental departments would make use of such Centres.

ACCESSIBILITY OF THE CENTRE

The countries selected should be easily accessible by air, land and sea. The more air and sea ports, the better. There are equipment that have to be transported by sea, while many would be air-freighted. If one sea or air port is faulty or there are disturbances of any type, there should be alternative ports of entry. Furthermore, there should be a good national and international road network. The Centre should be as close as possible to such facilities. This would also be advantageous to the trainees as well as people who would take advantage of the Centres later.

MOBILITY OF PERSONNEL AND EQUIPMENT

There should be no restriction of movement of personnel and equipment beyond a reasonable level in countries chosen to serve as Centres. There would be other nationals as management and technical staff and there would be trainees and others who would consult the Centres either for the repair or servicing of their equipment and instruments. Such people should be able to move freely without unnecessary restrictions to avoid frustration and disappointments.

EASE OF COMMUNICATION

The telecommunication network within the country to be used as Centres, as well as with other parts of Africa, should be efficient. Information and the easy flow of it is extremely essential to modern-day technologies. The Centres should be well-equipped but they should not be an oasis in a country without an otherwise good communication network.

Operation, Funding and Management of the Centres

All types of equipment for field and laboratory work should be available at the Centres for training, loan or rental. There is some equipment that individuals or even private organisations may not be able to afford, and in any case may not need all the year 'round. Such equipment should be available at the Centre. There should be arrangements whereby either individuals, organisations or governments should be able to rent the equipment. The legal implications or modalities should also be carefully worked out so that the privileges are not abused by unscrupulous elements. Needless to say, the security systems should be extremely tight to avoid pouring money down the drain. The rate at which equipment and instruments disappear in some departments could be highly disturbing.

FUNDING AND MANAGEMENT

For the programme to be successfully implemented, there is the need for adequate or generous funding. The cost of equipment and instruments is highly prohibitive these days. This fact is further complicated by the global recession of the mid-eighties and the collapse of the world prices for African and Third-World agricultural exports and oil. All these seem to have joined forces to worsen the debt burden of most African nations. International and inter-regional bodies like the World Bank, UNDP, IAEA, UNIDO and UNESCO should provide the bulk of the funding for the establishment and maintenance of the Centres. However, the countries in each of the zones which the Centres are to serve should make some contributions to the annual budget of the Centres. The budget would be for the payment of personnel emoluments and allowances, purchase of equipment for training purposes, running costs and maintenance of utilities.

The management and technical staff for the Centres should be seasoned administrators, highly principled and experienced personnel who have proved their worth in the public and or private sectors, and who have distinguished themselves professionally.

Conclusion

Research and development in Africa will continue to remain retarded if the appropriate modern-day equipment and instruments are not available to prosecute them. The rapid rate of technological advancement promotes the release of new equipment into the market at such a rate that policy makers, scientists and instrumentation technologists have to make constant efforts to keep abreast of developments. The cost of this equipment is getting beyond the easy reach of individuals, private organisations and even many government departments as a result of dwindling budgetary allocations. Where the equipment is available, there have been problems with maintenance, repairs, servicing and the procurement of spare parts or adequately trained personnel.

The establishment of Centres all over Africa to handle these specific areas or problems is therefore a welcome idea for the advancement of research and the development of the populace. The task of planning and establishing these Centres is by no means an easy one, since there are many constraints, among which are lack of funds, time and inadequate or limited information. However, the longest journey starts with the first step and this has been taken in the right direction in this case.

References

Agency for International Development. (1990) *Research and Development Abstracts*. 16(7).

Agency for International Development. (1991) *Research and Development Abstracts*., 16(4).

Coyle, D.C. (1963) *National Development and How it Works*. The New American Library, New York.

Hawkins, J.C. (1949) *The Mechanical Equipment of Farms*. Farmer & Stock-Breeder Ltd., London.

Stolper, W.F. (1966) *Planning Without Facts*. Harvard University Press. Cambridge, Massachusetts.

World Bank (1987) *Agricultural Mechanization — Issues and Options*. A World Bank Policy Study. Washington D.C.

THE ADVANTAGES OF AN INSTRUMENTATION SERVICE CENTRE: THE HUNGARIAN EXPERIENCE*

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Introduction

The rapid industrialisation of several developing countries over the last years/decades has resulted in an even more rapid increase in the use of measuring and control instrumentation. The penetration of instruments into the areas/institutions such as industrial process control, telecommunications, research and development, testing laboratories, universities, metrology centres, agriculture, public health institutions, education services, etc., has been significant. Efficient use of national instrumentation resources is one of the important prerequisites as the instruments have become increasingly expensive and have therefore required larger and larger investments at the expense of operation and maintenance.

To reach maximum efficiency in the use of instrumentation resources in a developing country the following basic conditions seem to be expedient:

- Development of a well-designed, co-ordinated instrumentation acquisition policy.
- Establishment of a suitable environment for the operation of the instruments.

Establishment of the Instrument & Measuring Technique Service (MMSZ)

About 30 years ago, it was recognised by the Hungarian Academy of Sciences that the establishment of a sound instrumentation basis is required for the effective development of the economy, so the decision was made to establish the predecessor of the present-day Instrument and Measuring

Technique Service of the Hungarian Academy of Sciences (MMSZ). The Institute has some 30 years of experience in management and operation of instrumentation infrastructure and implementation of Hungary's instrumentation policy, while contributing considerably to the effective development of the country's institution-building.

The establishment and development of the MMSZ coincided with the fast development and widespread use of electronic measuring engineering during the past 30 years. The present structure and activities of this institution were formed on the basis of experiences which had been accumulated during the country-wide spreading of a completely new technique and as a result of overcoming of problems in connection with the lack of instruments, repairing centres and experts.

MMSZ is a profit-oriented service, working under the supervision of the Hungarian Academy of Sciences. Within its activities can be found a harmonious combination of identification of the equipment necessary for renting; acquisition; repair; maintenance; consulting; the measuring technique service; development of instruments; and training. The usefulness of this organisation — originally founded for the provision of services to research institutes — was recognised by several institutes and enterprises operating in other fields (industry, agriculture, public health and education) of the economy and they became steady clients of MMSZ.

Essential Elements of the Instrumentation Infrastructure

No doubt each of us is completely aware of the significant importance of instrumentation, the main components of which are equipment with spare parts, necessary documentation and expertise. These components are at the centre of all activities which are necessary for the smooth operation of instruments. Let us enumerate some of the main activities of instrumentation technology as follows:

- Selection and procurement of instruments
- Elaboration of an instrumentation policy in laboratories/institutes/regions/country
- Supplying the information required on specific instruments
- Providing the services necessary for operation of instruments
- Systematic calibration and control of instruments

- Solving of special measuring tasks

- Systematic upgrading of technical knowledge of engineers, technicians, etc.

DESCRIPTION OF STOKUM SYSTEM (SYSTEMS APPROACH)

As is well-known, there are a lot of approaches to the so-called instrument maintenance problem. The main characteristic of the Hungarian Stokum System which may distinguish it from the other approaches (Training Approach, Increased Resources Approach, Regional Approach to Locating Manufacturers' Representatives, etc.) is its systemic character, i.e., it is a systemic approach to this issue. The Stokum System involves all elements of instrumentation infrastructure and in this way it can be structured by its modules. The System has responsibility for managing all elements (consultancy, renting, repair and maintenance, development, measuring engineering and training) of the instrumentation infrastructure in a systematic way. The institute where all these elements can work in a harmonious combination is called the Instrumentation Service Centre (ISC).

FUNCTIONS OF THE INSTRUMENTATION SERVICE CENTRE (ISC)

The ISC has the following responsibilities:

- Provides advice on instrument and measuring engineering investments

- Repairs, maintains and calibrates instruments

- Rents instruments

- Performs measurements and tests requiring expensive instruments and special expertise

- Designs and produces the commercially non-available special-purpose instruments

- Provides theoretical and practical training in the use and repair of the measuring instruments

Figure 1 summarises these activities.

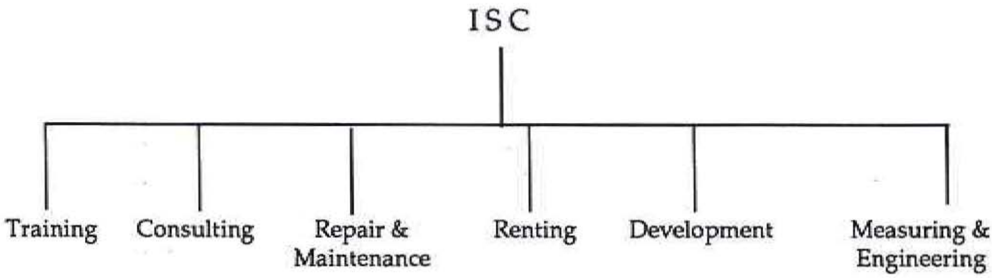

Figure 1: *Organisation of the Instrumentation Service Centre (ISC)*

Each of these activities provides a great advantage in the better utilisation of resources, and the application of each of them within the framework of an ISC can provide the following benefits:

- The efficiency of the instrument assets in question can be increased by almost one order of magnitude.
- The instrument and measuring engineering culture of the country in question would be increased to a considerable extent.
- The method of a complex technical-economical approach to instrumentation problems would be propagated.

Organisational Units (Modules) of the ISC

The elements or modules of the instrumentation infrastructure, or in other words the organisational units, of the ISC are as follows:

CONSULTANCY WITH THE NATIONAL AND REGIONAL REGISTRY OF INSTRUMENTS

The consulting activity is of national and regional importance in the implementation of instrumentation policy and the process of instrument investments. In solving a measurement problem, it is an important and a far-reaching task. The selection of the most appropriate measuring method and the instruments required cannot be expected to be done by any single individuals Even the most prominent experts working in commerce, agriculture, communication, public health, industry, or high-level education, can not be capable of solving in an expert-like manner the diversified new measuring tasks that might arise in their fields of activity.

The experts working in the ISC are all specialised in more restricted areas, within which they have great knowledge and professional experience; they know the professional literature and maintain contact with the most prominent specialists. They can assist in solving the most diversified measuring tasks; they can suggest the best measuring method for the individual tasks and can also provide advice on choosing the most suitable instruments. The experts know from practical experience the possibilities of procuring the instrument, the reliability of different suppliers, the drawbacks and the most favourable circumstances for business transactions. They can select the most suitable type of instrument from a regularly up-dated Prospectus Collection covering a wide range of instruments and equipment.

In addition to the technical characteristics of the instruments, it is also a very important aspect of selecting the most suitable and reliable instrument to ascertain — especially if it is manufactured abroad — if there is an easily accessible domestic repair and maintenance facility. Information relating to such repair and maintenance bases can be obtained from the National Instrument Service Register handled by ISC. Prior to procuring a more valuable instrument, it is especially important to take into consideration the experiences and references of the future users of the instrument in question.

The computer-based National Instrument Register may contain the technical specifications of all instruments above a specified value in regular use; the Register also contains the name and addresses of the instruments' users. With the help of this Instrument Register, the required references can be easily obtained. The National Instrument Register also provides assistance to those, who, in order to solve a given measuring problem, only occasionally look for measurement possibilities requiring instruments of higher value. In this way, the measuring problems can be solved quickly, it is unnecessary to purchase instruments which later on cannot be utilised properly, and the maximum and economic utilisation of existing instruments can be ensured.

The Prospectus Collection, the National Instrument Register and the National Instrument Service Register, as well as the expertise of the measuring engineering advisers, facilitate decision-making in connection with instruments and also facilitate the formulation of the National Instruments and Measuring Engineering Policy.

According to experience, the direct savings that can be achieved through the consulting activity, through choosing the right and most suitable type of instrument, and through economical operation and maintenance, can be estimated at the minimum 20% of the instrument's procurement price. This sum does not contain the excess profit arising from the safe operation of the instruments.

REPAIR AND MAINTENANCE OF INSTRUMENTS

All instruments need suitable service for their operation. Even the best quality and properly operated instruments can become faulty. For the repair and maintenance of instruments, experts with suitable basic qualifications (often with multiple skills, such as electronics, mechanics and specific training relating to the instrument obtained at the manufacturer) are required. Repairing devices and equipment (special tools, calibrating instruments, etc.), spare parts, and proper documentation are also required.

It is very important to provide all of these for the whole country in a concentrated way. In this way it is possible to utilise the experts' knowledge and the repairing devices and tools in the most efficient way in the interest of a high-level repair service.

A Consignment Spare Part Store can be established in which the components required for the repair of a specific instrument are in the possession of the instrument's manufacturer until they are actually required for repair purposes. This Consignment Store is especially advantageous in the case of instruments of foreign origin, when instead of occasionally procuring the spare parts from abroad — which is always a long procedure — they are readily available, while the costs of storage are, however, defrayed by the manufacturer of the instrument. This economic arrangement has allowed for a large amount of spare parts to be stored by the instrument manufacturers at their own expense in the central store.

The instruments can be repaired in the Central Repair Workshops, but in the case of larger instruments, ISC travelling service experts perform repair jobs actually on the premises of the user. Within the framework of the preventive maintenance system, the condition of the instrument is regularly checked and the necessary adjustments are performed, even where the instrument is still capable of fulfilling its basic functions, thereby helping to prevent failure of the instrument at a later date.

All over the country, the ISC, as a specialised service centre, repairs and maintains instruments manufactured by several dozens of foreign manufacturers, including several multinational companies. Within the framework of this activity, the manufacturing companies train the engineers of the Centre in the repair of instruments, provide repairing documents and special repairing tools, and establish consignment spare parts stores in order to speed-up repair jobs. In addition to classical electronic instruments, the repair and maintenance activities have also to cover the instruments and equipment used in several fields of the economy.

In many cases, on behalf of the foreign instrument manufacturing partners, the ISC repairing experts perform jobs not only within the country, but also abroad, primarily in neighbouring countries. This international regional activity of the Centre constitutes a foreign exchange revenue for the country and at the same time it is an important contribution to the domestic introduction of advanced technology.

RENTING OF INSTRUMENTS

This service implements the efficient use of instruments needed intermittently and in considerable quantity for research and measuring tasks.

As it becomes more and more difficult to provide money for procuring up-to-date instruments, the users cannot keep abreast of the quick developments in the field of measuring and instruments techniques. This problem can be successfully overcome by taking into account the fact that in certain cases, the demand for a given instrument does arise continuously, but only periodically and for a short time. Instrument rental can be useful in the following cases:

- If the instrument used continuously is getting faulty and it is necessary to continue the measurement during the repair period.
- If an instrument otherwise not used is required in a special measuring set-up, particularly for R&D purposes.
- When it is periodically necessary to check the existing measuring system with the help of a parallel measuring system.
- When a new model of instrument could be tested before purchase, so that the procurement of an unsuitable instrument can be avoided.

Such demands can be met in the quickest way and with the least possible cost from a properly established central stock of instruments. The Instruments Renting and Leasing Service of the ISC serves this purpose.

Conditions for efficient instrument rental include the following:

- maintaining an ample stock of the most up-to-date instruments for meeting the current demand;
- establishing one's own repairing, checking, and calibrating laboratory;
- quick administration.

Upon renting, the customer receives a faultless and calibrated instrument. Before leasing, the instrument is checked whether or not it meets the original technical specifications; if the instrument gets faulty while with the customer, it will be quickly repaired.

Other advantages of instrument rental include

- Improved utilisation of instruments assets. According to experience, the instruments in the rental stock are utilised on average 6 to 8 times better than those individually purchased by the customers.
- The required instrument is readily available.
- The users are not burdened with repair and calibrating problems.
- Through the Central Storage Unit, considerable savings can be achieved in the auxiliary and semi-fixed material consumption.
- In the case of leasing, investment capital can be saved.

The so-called Co-operation Renting is a special renting service. Within the framework of this special renting service, in return for the rental fee, ISC takes over the instruments which are not used temporarily by their owners and hires them out to other users who are looking for such instruments.

MEASURING ENGINEERING

For solving a measuring task, it is frequently not enough to possess the instrument. Special theoretical and practical experience are also needed. Examples of this are the processing and evaluation of the large mass of data provided by up-to-date measuring techniques, or of the handling of automatic measuring systems, or measuring with set-ups containing several measuring instruments.

If such measurements are only occasionally required, it is worth renting not only the necessary instruments, but it is also advisable to hire experts to operate them. Through this service the customer receives a perfect solution to his measuring problem and also receives numerical results and data collected by high-level personnel which can readily be used for decision-making.

The main fields of measuring engineering include:

- Testing of mechanical structures (vibration measuring)
- Acoustic tests (noise and vibration measuring)
- Making of films/video films (examination of quickly- and slowly-changing phenomenon, etc.)
- Thermal and infra-technical measurings
- Loading and interference tests of electric networks, etc.

INSTRUMENT DEVELOPMENT

An important service of the ISC is the development of special-purpose instruments and sensing/converting instruments. The Special Instrument Development Activity has been growing on the bases of the experiences of the measuring techniques and instrument renting services. Very frequently such measuring demands arise — especially in the fields of education, research and development — which cannot be met by means of commercially available general-purpose instruments, and therefore a special unit with a construction and technical specifications suitable to the given measurement task is required. The accumulated theoretical and practical expertise offer a quick, high-level and economic solution to special problems.

EDUCATION AND TRAINING

An up-to-date level of technical expertise can only be maintained through continuous and systematic upgrading. It has been shown that the lack of a thorough theoretical and practical knowledge in connection with the measuring task can greatly hamper the full utilisation of the technical potential of an instrument. Therefore, the educational and training activity of the Centre is extremely important.

The experiences collected by ISC personnel based throughout the country are directly transferred to the education and training personnel of the ISC. In this way, the teaching material for the regular instruments engineering and measuring technique courses can always be provided, according to the most timely demands and needs.

The experts of the ISC are at the disposal of the customer not only when advice is needed in connection with investments. They also help in the development of the measuring method. If the user of the instrument should get stuck in solving a given problem, either individually or on organised courses, he can acquire the theoretical and practical knowledge required for performing the measuring task and he can also learn how to handle, repair and maintain the instruments. On the organised courses, the lecturers are the most prominent domestic or foreign experts and authorities on the subject in question and for technical instruction on instrumentation, can be selected from among the experts of the manufacturing company.

Implementation of a Modular Approach

The Hungarian modular system approach can serve both for the implementation of a national and regional instrumentation policy and at the same time for the effective and self-financing management of the instrumentation infrastructure. There is always a large variety of possibilities to construct a possible system (which depends of course on the site conditions) from modules. To find out the suitable steps, the most effective solution is to cite a careful and comprehensive survey and study.

It should be stressed that in Hungary these modules have arisen through a continuous development from the need to meet the requirements of the clients. These modules/units resulted from the synthesis of the activities necessary for the operation of instrumentation and they can support each other in parallel, or can operate independently in a complex system. For instance in Hungary, MMSZ began its activity with the **Renting Module**. In this way it was possible to save convertible currency, as it was emphasised, which could help the procurement. The renting activity needs its own service basis for the necessary repair and calibration work. This was the basis of the **After Sale Service Module**. There was always steady demand for the **Advisory Service,** too, since all responsible decision makers needed information before making a decision. To satisfy this requirement the **Consultancy Module** was implemented.

The demand for solving special measuring, and controlling tasks was presented throughout the whole national economy, so the **Measuring**

Engineering Module was established. When these modules were put together in the Institute, the basic expertise necessary for their development was available, and to explore this possibility the development of single-purpose instruments/systems could be started. Without **training and education**, it is impossible to perform any work, so this module was needed to operate the system. And if an institute provides training and education for its own engineers, there is the possibility for arranging courses for outside engineers, too. The co-operation of units furnishes a great surplus of experts available for training.

The modules can be implemented individually or in the same or any other combination in new centres or existing institutes in order to meet the specific needs of a country. According to the conditions of the country, the implementation of ISC can be started by any of these modules. The continuous development of industry needs an effective operational background for the instrumentation which serves all fields of the economy; this background can be implemented and effectively managed by the ISC. In this way, in addition to bureaus of standards, metrology offices and quality control institutes, ISC also has to be involved in the infrastructure of institutions, especially in developing countries. The result of the implementation of the ISC is increased cooperation among all elements of the instrumentation infrastructure and more efficient equipment acquisition and use.

COST OF AN ISC

Taking into consideration the generally existing building and infrastructure (necessary at the first step) the establishment of the basis of an ISC needs a value of US$ 1.5–2.0 million for equipment, expertise, software and training. The training can be implemented in an operating ISC like MMSZ in Hungary.

The present organisation of MMSZ can be a model to be worked towards, and its elements may be applied selectively in accordance with the circumstances in each case. The site conditions may be surveyed in a Preparatory Assistance Phase. Through the application of the Systems Approach (Stokum System) the stepwise improvement of the instrumentation infrastructure can be accomplished in a flexible way.

In such a system, the ISC can be placed within a single/national centre, can be structured either as a profit-making venture or as a government-financed institution, depending on the institutional structure of a country or region. ISC, as a profit-oriented enterprise, could ensure the improved utilisation of the personal, financial and technical resources already available in the country. Such a Centre is especially of great importance in those countries where not only the scarcity of material resources is a problem, but where the wide-spread application of measuring techniques is often hampered by the absence of sufficient number of experts, who could operate and repair the measuring instruments.

UNIDO/MMSZ Cooperation — Applications in Other Countries

The system developed by MMSZ was introduced to the United Nations Industrial Development Organization (UNIDO) in 1986 whilst the newness of this approach and its adaptability in developing countries were just being recognised. This opinion was confirmed by the First and Second UNIDO Inter-Regional Workshops convened in Budapest in 1987 and 1990. During the Workshops, recommendations were accepted which determined the preparatory tasks of a programme to develop the developing countries' instrumentation infrastructure.

Although it cannot be claimed that UNIDO was able to follow up all recommendations of the Workshops, there are a number of positive developments. Several instrumentation-related projects have been identified, formulated and even implemented. The following are examples:

- Centre III in Ho Chi Minh City, Vietnam
- Regional Instrumentation Services Centre in the Republic of Korea
- Precision Instruments Repair and Maintenance Facility in Nepal
- Design and development of low-cost instruments in Vietnam
- Instrumentation Services Centre in Indonesia
- Expert systems for repair and maintenance of process instruments in a number of countries.

In addition to the training provided in connection with the above-mentioned projects, specialised training programmes in the fields of repair and maintenance of biomedical instruments, microprocessor-based instruments, and instrument repair using interactive video and computer programmes were planned and/or carried out.

CASE STUDY: IMPLEMENTATION IN VIETNAM

The Vietnamese counterpart took part in the above-mentioned First UNIDO Workshop and as a follow-up of this conference, the decision was taken to implement the Stokum System in the South Region of Vietnam. Before the Project Formulation Phase, the priorities were defined by the Vietnamese counterpart of the Centre III of General Department for Standardization, Metrology and Quality Control, or briefly "Centre III". They decided to implement the Repair and Maintenance with After Sale Service and the Consultancy modules in the first step.

The most important groups of instruments to be serviced were determined. In this way the control and measuring instruments which were necessary to the service activity could be selected. All preparatory engineering work (e.g., acquiring quotations from different suppliers) to be able to make an optimum choice, considering the limited funding available for purchase, was carried out at the time of approval of the project. In this regard it is necessary to take into consideration the exchange rate of currency in future. If this fact is not considered during the preparatory phase, it is not possible to determine a realistic estimation for the cost of equipment and services and to make the optimum choice of equipment.

On approval of the project, all valid offers of different suppliers for the equipment were at their disposal, so the final selection of equipment could be carried out during the requisition procedure.

The project schedule was planned for a two-year period. To use this time effectively, the Chief Technical Advisor (CTA) began his work on the site during the approval's procedure stage. To be able to carry it out, the Vietnamese partner put the proposal for the CTA to the UNIDO before the approval. The identification procedure could be accomplished in this way during the preparatory period. Centre III also selected the candidates for the training during the preparatory period. This made it possible for the Centre III together with the CTA to finalise the selection of the trainees at the beginning of the project. The UNIDO made all necessary preparations at the ISC in Hungary so the training could be commenced in the first month of the project.

The trainees consisted of two groups, managers and engineers. The managers had a one-month special training course where they were introduced to the inherent characteristics of the Stokum System and the management of a complex ISC. This helped them to organise their work on the site and enabled them to develop their activities in a step-wise manner. The engineers also got a brief training in the inherent characteristics of the complex system; however, the largest part of their training was comprised of the practical methods of repair activities, the philosophy and methods of trouble-shooting, and the use of the equipment to be purchased.

The purchase orders for the selected equipment were placed by UNIDO parallel with the training in Hungary, and in this way all the essential equipment were delivered to the site before training was commenced at Centre III. The identification of international consultants was also carried out during the equipment delivery period (they were selected from Hungary) so the training could begin just after the arrival of the equipment. This made it possible for the on-site training to be carried out on the equipment actually purchased.

After the above steps were taken, more than one year remained of the project time in which to determine the spare parts necessary for the most important repair and maintenance work, to train the engineers of Centre III and to develop the range of Centre III's activities. During the preparatory activities and the implementation stage of the project, the consulting engineering activity was provided by MMSZ of Hungary in close co-operation with UNIDO and Centre III. This close co-operation and the resolute work of Centre III helped to solve all problems raised during the implementation and made it possible for the Maintenance and Repair Centre to start the complex work of the first ISC in Vietnam.

In January 1991 the first regional Workshop was organised by UNIDO to present the experiences of the successful implementation of the Regional ISC (adaptation of the Stokum System) in Regional Centre III in Ho Chi Minh City. The experience gained in this implementation showed that the modules of the system are very flexible and can be adopted step-by-step if they are selected according to a given set of local requirements.

RECOMMENDATIONS FOR ESTABLISHMENT OF SUB-REGIONAL ISCs

The Workshop recommended among others that UNIDO should:

- Carefully taking into account the typology of regional countries, emphasise to Governments the importance of instrumentation policies with special attention to repair and maintenance of instruments and assist requesting developing countries in creating their own Instrumentation Services Centres (ISCs). It is understood, however, that each requesting country would select the modules appropriate to its local conditions.

- Undertake ground work for the establishment of sub-regional ISCs which will serve participating countries with fairly similar development levels.

- The feasibility of creating a sub-regional ISC in Southeast Asia covering Cambodia, Laos, Myanmar and Vietnams hould be studied. With its fairly advanced state of development, Centre III can play a focal role in such a regional project. Therefore, completing the missing modules of Centre III should be supported by UNDP/UNIDO.

- Another sub-regional ISC should be created for SAARC countries, if it is found feasible.

The request for technical assistance to establish a Sub-regional ISC for Cambodia, Laos, Myanmar and Vietnam using the implemented Regional ISC in Ho Chi Minh City as the focal institute was submitted to UNDP/ Hanoi, and the preparatory actions for this project have been commenced.

Conclusions

Within the framework of the UNIDO-MMSZ cooperation, the MMSZ stands ready for the transfer of its accumulated knowledge and experiences. On the basis of local characteristics and requirements, development priorities can be decided. MMSZ as a sub-contractor can also design and implement complex institutions or centres specialised in a given field of activity. In case of need, experts can be sent to the spot or courses can be organised in the MMSZ using up-to-date teaching aids to transfer special technical, economical and organisational knowledge. Through selecting the required equipment, machines, instruments, and by training fellow engineers/technicians, assistance for more efficient management of existing instrument assets and measuring engineers can also be provided.

All of these activities are pursued on the basis of co-operation, or contractual agreements according to the auspices of international organizations (UNIDO) under favourable conditions.

*This paper was not read at the Workshop, but the organisers recognise its importance and have therefore included it in these Proceedings.

GENERAL DISCUSSION ON ESTABLISHMENT OF INSTRUMENTATION CENTRES

Discussant Panel:	A. Abdinaser	–	UNESCO, Kenya
	A. Menyhard	–	IFC, Hungary

Abdinasser, *Kenya*: Think of establishing small centres in each country and think of their future survival to avoid death after inception. Centres should be composed of various committees with representatives from research institutions. For specialised instruments, centres need to be established at sub-regional level. It is also important to think about the updating and upgrading of service personnel by further training.

What are the reasons for lack of enough support by Governments, e.g., in the RCSSMRS case where only 12 out of 22 countries are signatories?

Ambani, *Kenya*: The Centres themselves should be able to determine the rules for membership and subscription rates. Charges for services also need to be fixed, e.g., for repair work.

Ngundam, *Cameroon*: It would be a good idea to design an evaluation scheme on the impact of training.

Job cards should include the date of last service and the cumulative charges. The Centres could be self-financing through their service charges.

Rajese, *Lesotho*: What action has been taken by the RCSSMRS on defaulting countries?

Answer: Subscribing states are not charged on R&M as a cost-benefit inducement.

Menyhard, *Hungary*: The IFC is now 35 years old with US$ 6 million in revenue; it started with rented equipment. An Instrumentation Centre (IC) should start at a low scale then develop stepwise. The IC can handle instrumentation jobs at institute level and provide the basis for making a national instrumentation policy. The operational aspect requires money, however, an IC needs an effective management, who are well-aware of its objectives.

Technicians need to be trained in the use and repair of equipment. On-the-job training is more effective, with the trainee serving with a service engineer for a period of not less than 3 months.

Oguntoyinbo, *Nigeria*: IC modules will grow with the Centre — i.e., there will be more modules as the Centre grows. The Workshop should lay the framework on membership of the IC networks and the regions.

Okoyo, *Kenya*: Expensive test equipment might be purchased for training but may not be available to users. The University of Nairobi is setting up a consultancy in electronic maintenance.

Jagne, *Gambia*: The location of the IC will depend on existing infrastructure. Regarding funding — the IC goal is to be self-sustaining through repair charges, publications, consultancy, etc.

Gurkok, *Vienna*: UNIDO will support the IC but requires eventual self-sustainability. This implies a good credibility image and sure markets.

CHAIRMAN'S SUMMARY

- One Regional Centre with other smaller centres in each country is required.
- African Governments must be willing to support such Centres.
- There is a need to upgrade existing skills of maintenance and repair personnel.
- Evaluation of training programmes is vital.
- Consider on-the-job training of not less than three months' duration.
- Use of computers should be encouraged, due to their cost saving.
- Take stock of existing Centres and then make rational decisions on the starting levels.
- Start on a small scale.
- Rent equipment if there is insufficient money for purchasing new models.
- An instrumentation policy is needed at regional, sub-regional, and national levels.
- Consider that an IC requires an operational budget.
- Recruit strong management personnel.
- Regarding sustainability, the IC has to be credible, and must have proven markets.
- Sensitisation of consumers for using these Centres must be done.

SESSION V

NETWORKING OF INSTRUMENTATION CENTRES

CHAIRMAN: C. Gurkok

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THE ROLE OF A NETWORK FOR USERS OF SCIENTIFIC EQUIPMENT IN SUB-SAHARAN AFRICA

M.M. Lung'wecha

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Morogoro, Tanzania

Introduction

Scientific research and training in most developing countries have been operating under very difficult conditions. This has mainly been ascribed to the poor status of the laboratories and lack of trained personnel. In fact in many institutions, the problem has led to stagnation of certain aspects of scientific research. The problem is even more serious in the teaching of science at secondary schools. Some schools have been opened and run on a private basis by parents' associations, religious bodies or individuals. In such schools, the bare minimum requirements are classrooms and the condition of laboratories has been given the lowest priority. This state of affairs has penetrated even the government-run institutions, research institutes, technical colleges and the universities. The problem is therefore a vicious cycle, in that at all levels, the graduates are deficient in one way or another.

Based on the above, it would appear that institutional development at all levels has overlooked the role of well-stocked laboratories in the advancement of science and technology. However, this trend is not intentional, and the whole problem may be ascribed to weak financial resources in many developing countries. It is based on this premise that the International Foundation of Science (IFS) organised a course on the "Training on Operation and Maintenance of Scientific Equipment for the SADCC Countries" in Harare, in November, 1989 The broad objectives of the Harare meeting were to draw together technical staff and researchers in scientific instrumentation; create a network of collaboration for solving problems of equipment in the SADCC region; and to broaden the technical knowledge of proper operation, repair and maintenance of scientific equipment.

The course was practical-oriented and was attended by more than 40 participants involved with scientific instrumentation from the SADCC countries.

Establishment of a Regional Network (NUSESA) for Southern Africa

One of the major achievements of the Harare meeting was the creation of a formal organ for communication among equipment users in the region, the "Network of Users of Scientific Equipment in Southern Africa" (NUSESA). The operation of NUSESA is based on national committees which have currently been set up in various SADCC countries since the Harare workshop in 1989. The national committees have a hard task ahead of them, for in most cases they have to start from the scratch because of the many constraints they face, including

- lack of properly stocked laboratories;
- inadequate numbers of properly trained technicians;
- critical shortage of funds, both local and foreign, for purchase of equipment and chemicals;
- lack of honest and reliable firms to offer servicing of equipment at reasonable prices, etc.

DIRECTORY OF PERSONNEL

In order to have a common starting point, the national committees were charged with the responsibility of compiling a directory of personnel in the SADCC region with skills in the operation and maintenance of scientific equipment. This will provide a picture of the status of resource personnel available for advising on the repair and servicing of scientific equipment in the region. This will be sustained by a newsletter covering various aspects of scientific instrumentation in the region which will be funded by IFS in its initial phases.

An active regional network will depend entirely on the strength of the national programmes(committees). In Tanzania, for example, the National NUSESA has been launched and registered officially. The membership is swelling at a very satisfactory pace. So far, the national committee has held one workshop/training course on Microscopy (June 19–22, 1990) and it drew participants from six institutions(research, university and secondary schools).

CONSTRAINTS ON PURCHASE AND MAINTENANCE OF EQUIPMENT

In addition to the main objective of the course, participants had an opportunity to discuss the status of equipment at their institutions. One point that became clear is that many institutions lack even the most basic scientific equipment, and with the little that is available not in working condition. This observation was confirmed by the IFS representative Dr. Lennart Prage during the Dar es Salaam Workshop on Operation and Maintenance of Scientific Equipment in the SADCC Countries in November 1990 when addressing journalists at Dar es Salaam (*Daily News*, November 1st, 1990). According to Dr. Prage, about 35% of the equipment in the SADCC country institutions are defective, hence making it difficult for scientists to conduct research effectively.

There are several reasons which can be advanced for such a situation. Most of the member countries of SADCC do not have a source of foreign currency to purchase scientific equipment, and as a result, they depend on donor agencies to supply various equipment. Such a supply is not accompanied by a package for servicing and maintenance. Since most institutions do not have trained personnel to maintain them, the equipment is normally shelved once they go faulty.

The NUSESA and its national committees with the assistance of IFS are tackling this basic problem. Such a network will go a long way in sensitising the decision makers in the respective SADCC countries to inject local funds and solicit foreign currency for purchase of scientific equipment and for the training of local personnel on their proper use and maintenance. It is hoped that over time, a critical mass of trained personnel in management of laboratories will be created and take over the responsibilities from foreign experts. This will save a lot of foreign currency currently being used in the importation of foreign experts and divert it to other developmental programmes (Peter Keay, *Daily News*, Nov. 1st, 1990).

NEED FOR TRAINING OF TECHNICIANS

In order to design a mode of operation of a network, it is important to survey the current situation in the region. It is known that there is a lot of scientific equipment in the schools and research institutions within the SADCC region. In addition, there is a further flow of more equipment for research projects supported by donor agencies, particularly in the universities and research institutions. However, the researchers(users of scientific equipment) are not trained to service and maintain the equipment. Hence, there should be specially trained technicians to use such equipment, service them and make repairs when necessary. At present this is the major drawback of the whole research system in any of the SADCC countries.

The training of researchers is not complemented with a concomitant staff-development programme for technicians who actually carry out the work for the researchers. Much as it is known that there is no ready-made formula for problems related to scientific equipment, solutions should be tailored to meet specific needs. This is where an inventory of equipment and personnel within the region becomes important.

Operation of the Network

For the effective operation of a network, the following are recommended:

- *Establish effective national committees* to handle local problems related to scientific equipment. The committees will prepare/compile and distribute a list of equipment and expertise within the country.

- *Compile and distribute a list of suppliers* with prices of various equipment for the country and update it from time-to-time. This will enable individual institutions to make their orders according to their needs.

- *Organise training workshops/short courses for technicians and young scientists* on the proper use, servicing and maintenance of scientific equipment. Such meetings will keep participants abreast of new equipment being developed and their use, and enhance their laboratory management skills.

- *Invite policy makers such as science councils to the national committee meetings* so the network will be able to sensitise the decision makers to allocate adequate funds for purchase of equipment and training of technicians.

- *Organise writers' workshops to write manuals* on a number of areas of laboratory management, such as on laboratory techniques such as chromatography, spectroscopy, microscopy, laboratory safety, staining techniques, etc. Such manuals will reflect the type of equipment commonly used in the various institutions in the member countries of the SADCC, thus meeting the local needs.

- *Develop equipment locally* in order to save on foreign currency, which is the major constraint in acquisition of scientific equipment.

- *Maintain a sustainable collaboration between researchers and technicians* at various levels.

- *Establish national and regional data-bases on the major scientific equipment and personnel* with skills in operation and maintenance of scientific equipment.

- *Maintain national and regional newsletters* which will aid in dissemination of information on acquisition, servicing and maintenance of scientific equipment and laboratory management to members of the network and research and educational institutions.

- *Collaboration of the national committees with the Regional Secretariat* will establish a strong and sustainable network and hence alleviate the current problems of scientific instrumentation and research in general.

NETWORKING INSTRUMENTATION CENTRES — A FACTOR FOR TECHNOLOGY TRANSFER IN REPAIR, SERVICING AND MAINTENANCE*

J.M. Ngundam

Automation and Control Laboratory
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Yaounde, Cameroon

Introduction

Laboratory equipment for teaching, research or simply industrial commercial services cost African nations dearly, in installation ,repair and maintenance. These costs may vary anywhere from two to four times the amount charged in more developed countries. In certain cases, the absence of adequately trained technicians requires that foreign experts are called in to install and repair and/or maintain them. Some countries have been known to abandon perfectly good equipment requiring simple maintenance for a new product, as a solution to the lack of technicians and spare parts. Government and semi-public institutions in most African countries are very fond of this particular practice.

The general need for trained technicians is very acute in the public and semi-public sectors of the economies of African countries. This is not to say that the private sector can find all the technicians needed to run workshops, production lines, laboratories, etc. In an environment where significant shortages in adequately trained and knowledgeable technicians are constantly evident, public and semi-public sector incentives for technicians are less competitive when compared to those of the private sector. These institutions either do not find technicians to hire or if they do, the quality may be very inferior indeed.

Instrumentation Centres

The creation of instrumentation centres to serve geographical regions such as the Northern, Western, Central, Eastern and Southern African regions, for example, may be used to solve the problems linked to purchasing of equipment, spare parts acquisition and inventory management, repair and maintenance training or even equipment hiring and rental.

Equipment purchasing could be standardised and limited to a number of known trademarks. The Centres will then purchase in bulk at preferential prices directly from the producers. Each Centre will be able to supply contributing members with equipment and spare parts at affordable prices. In cases where institutions may not require specific equipment for long periods, the Centres could rent or hire out whatever is needed at moderate prices. The management of each Centre must make sure that all equipment purchased should come in with the necessary documentation needed to carry out maintenance and repair work.

The role of each Centre should not be limited to that of a clearing house for member institutions. It should design and carry out research on equipment operation in the various geographical environments they represent. A computerised inventory of equipment and spare parts must be kept.

Research data on equipment in different environmentally hazardous conditions could be computerised and compared with data coming in from various institutions using the same equipment types. Based on this data, equipment handling procedures can be produced by the Centre for distribution to member institutions. Maintenance and repair courses are thus prepared and delivered. Statistical forms for each equipment make and type are prepared and distributed to equipment users. The breakdown and maintenance history of each equipment is updated on such forms and returned to each Centre for computerisation. Equipment calibration and installation should be undertaken by the Centres on behalf of members at preferential prices.

Financing the Centres

Each Centre should become self-sustaining in the long run. The profits should be just enough to maintain the Centres and pay salaries of the personnel. This implies that each user should pay a reasonable cost for all services rendered. Member governments or institutions falling under the zone of influence of each Centre should provide the initial investment funds for purchasing equipment spare parts and maintenance of the Centres. After this initial stage the Centres should be self-financing.

The Centres may not compete with private enterprise in the purchase and supply of equipment and spare parts. In fact, such equipment and spare parts may be supplied to public research and educational laboratories at prices that are affordable, even if only marginal profits are to be made. All research data and training programmes should be made available to the private sector at market prices.

Contributing members of the Centres could be given some price concessions in order to lighten their financial burden. By contributing members, we refer to public and semi-public institutions whose governments are co-owners of the Centres. The Centres could consider renting or hiring equipment to laboratories that cannot afford to purchase directly.

Siting of Instrumentation Centres

The Centre representing each geographical region should of necessity be established in a country with a high level of technology assimilation, availability and quality of experts and engineering schools or technician-training institutions. These requirements are obvious, for the simple reason that such a country, as compared to its neighbours, has the capability of adapting and assimilating a new technology faster as a result of the quantity and quality of its technical and engineering schools. The establishment of an Instrumentation Centre for a given geographical region in such a country will encourage intellectual interaction between universities and technical colleges and the Centres. The proximity or location of the Centres in such relatively advanced environments will accelerate the rate of technology transfer to the Centres. Each Instrumentation Centre can consequently carry out applied research on new technologies linked to specific equipment it supplies to customers and thus is in a position to adapt the technology and design methods of assimilation suitable for easy transfer to its customers. As Centres of Excellence, these Instrumentation Centres must collectively keep up with the level of technology needed in each region by accelerating the assimilation process. The argument for situating Instrumentation Centres in relatively more advanced countries of each of the sub-regions is based on theories put forward by Nawaz Sharif and Haq (1980), who cited the following fundamental premises of the technology transfer process:

> "There must be a supplier and recipient of technology. In the specific case of the centres being discussed we have two different levels of technology transfer: (i) manufacturer to Instrumentation Centre, and (ii) Instrumentation Centre to its customers."

- "Instrumentation Centres acquire equipment and technology, calibrate equipment and adapt the technology for each location. They train customers on installation and operation standards and repair and maintenance procedures.

- Any particular technology, in most cases, is a complex combination of many component technologies (e.g., a system has many sub-systems), which can be transferred from different sources (from one country or even different countries).

- The recipient usually lags behind the supplier in terms of a particular technology.

- The discrimination between different locations is due to different spatial characteristics and is characterised by the technological level.

- The degree or level of a technology mastery required to perform a given function or satisfy a particular need depends on the technological level of the source of the technology.

- Technology flows because of the difference in technological levels (technological gap) between supplier and recipient.

- Technology developed at a location is designed for the conditions prevailing in that location. Hence, technology needs adaptation at the receiving end.

- The capability of adaptation and its assimilation (diffusion) by the recipient is determined by its technological level in relation to that technology and the technological level of the source.

- Assimilation by the recipient is the result of effective technology transfer."

The nine points as enumerated above imply that the rate of assimilation of a particular technology at a given location at a certain time is proportional to the existing level of assimilation and the level remaining to be achieved. It is evident that an Instrumentation Centre surrounded by numerous high-quality engineering and technical schools will have a high level of assimilation of most technologies as compared to one in a location of new institutions of dubious quality. In addition to the nine points we might add,

- The availability of high-quality experts as full and part-time staff at each Centre, and

- Collaborative research work undertaken jointly between the Centres and neighbouring engineering schools and laboratories which should increase the level of assimilating technology of the Centres.

The last two factors will further improve the efficiency and effectiveness of the Centres as islands of excellence for technology transfer (equipment, spares, installation and maintenance, training, inventory, management and costing, development of standards of operation and maintenance, etc.). In short, the Centre will be expected to register a technology gap equal to zero or close to zero for all new technologies its customers are interested in (Nawaz Sharif and Haq, 1980). The technology gap is given by:

$G = Ix - Iy$, where
- Ix = technology index (the measure of technological level) of the suppliers x
- Iy = technology index of recipient y

The technology gap determines the flow of technology between the equipment manufacturers, and suppliers to the Centres on the one hand and from the Centres to the customers they serve on the other. If the technology level of the Centres is very high, so is the absorption rate of such technology bound to be high. Now the diffusion of the technology from the Centres to their clients is a different matter. It will depend on the

- technological infrastructure available
- availability of locally trained personnel
- need for and ability to pay for the technology

Obviously, the technology gap is bound to be different for different clients in the same geographical region. The index Iy is therefore a function of the three factors listed immediately above. The assimilating capacity or level parameter of the Centres or the clients as Sharif and Haq suggest, is given by the variable termed Potential Technological Distance (PTD), or D for short, which is defined as:

$$PTD = \frac{\text{Technological Gap between the Supplier and the Recipient}}{\text{Technological Level of the Recipient (Iy)}}$$

In other words,

$$D = PTD = \frac{Ix - Iy}{Iy}$$

By choosing Centres in locations with a generally high technological level, the idea is to reduce D to zero. Yet for each client that uses the services of the Centre, D varies between zero and infinity. The rate of assimilation of each technology (accelerating the decay of D towards zero) should be influenced by the activities of the Instrumentation Centres. This could be done through providing cheap equipment adapted to the needs of the clients and to follow up with regular training programmes on installation, repair, maintenance, inventory management and development of a statistical history of equipment in use.

Networking Possibilities

The impact of information technology (IT) in all human endeavours and in the special case of Africa should be seen in the context of Information Storage, Retrieval Processing (ISRP) on the one hand, and information dissemination on the other hand, (Kwankam and Ngundam, 1984a). These authors consider ISRP technologies as including manually operated microfiche systems to large data bases using mainframe computers and information transmission and reception (ITR) technologies, hard-wired techniques through microwave and satellite linkages, and associated hardware in the category of information dissemination.

The level of assimilation of IT will affect the impact of networking on information documentation and exchange among different Instrumentation Centres on the one hand and between Instrumentation Centres and clients on the other. Modern telecommunications facilities provide channels for hooking up individual computers with equipment data into computerised IT networks. Individual computers of clients could be hooked up to mainframes installed at Instrumentation Centres representing each geographical region. Exchange of documented information on technology equipment and its history can be carried out directly, speedily, efficiently and almost instantaneously. The exchange of documented information among Centres is also possible through hooking up their mainframes in the same way. The availability of communication satellites will further facilitate the process of exchange of documented information.

Computerisation of information in relation to technology, equipment, its history (standards of installation and user, failure, repair and maintenance) can be done cheaply these days because of the falling costs and the increasing capacities of microcomputers. Each of the clients can afford this technology at the present time and all laboratories could be encouraged to computerise all documented information on any installed equipment in use. The exchange of information must be based on market rates. Each laboratory must have an interest in keeping efficient records and should be paid a fair price for the use of its documented information. The possibility exists for each individual laboratory to contribute to technological development by providing much-needed information on its equipment and at the same time making money through such contributions. The exchanges among laboratories and/or centres should directly contribute to the cost-sharing required in running the system on the one hand and improving the accounts of contributors on the other.

Networking and Training

Kwankam and Ngundam (1984a) define networking as the establishment and exploitation to mutual advantage, of formal links among institutions with similar goals. The infrastructural similarity of Instrumentation Centres and the clients they serve, their commonality of problems and the individualistic approaches to achieving their common goals make networking an attractive aspect to consider.

Laboratories of all kinds established in Africa are known to be less effective working alone. The problems of acquiring and maintaining equipment has been discussed above. A major factor contributing to the problem is the inadequacy of technicians in numbers and quality. The pooling of resources in the form of equipment, knowledge and information has been discussed. However, the skills of technicians operating equipment and those concerned with the repair and maintenance require a constant and consistent updating programme. Again, the effectiveness of each institution in meeting these objectives is considerably improved if resources are pooled into the network. This assertion is modeled by Kwankam and Ngundam with the expression for effectiveness.

$$gJ = bJ/aJ, \text{ where } aJ = \text{input}; bJ = \text{output}$$

The above authors further stated that in a network of N institutions, the effectiveness becomes

$$g'j = (bj + yj + \sum_{i=1}^{n} zji)/(aj + xj)$$

where

xj	=	the contribution to the network
yj	=	the direct benefits from the network
zji	=	the indirect fallout benefits as a result of contact with the *ith* institution

The above equation could be rewritten as:

$$g'j = bj\,(1 + dj + ej)/aj(1 + cj)$$

When further simplified, this equation becomes :

$$g'j/gj = (1 + dj + ej)/(1 + cj)$$

The above model shows that for a net improvement to be achieved, the following condition is required:

$$(dj + ej) > cj$$

The above model applies both to information documentation and exchange, and to training programmes run from Centres with active participation from members of each Centre as well as among Centres. This form of cooperation (laboratories operating around Instrumentation Centres acting as islands of excellence with all being connected into a network) eliminates costly duplications (Kwankam and Ngundam, 1984b; UNIDO). On the question of training, the use of IT tied into communication channels that include satellites will raise the level of the effectiveness and efficiency of training programmes. Live demonstrations could be followed from television screens. In cases where television screens cannot be hooked up to the network, video cassette recordings of training programmes and conferences could be made available through each Centre to the individual laboratories concerned.

Information, transmission and reception (ITR) technologies such as modern teleconferencing methods can improve teaching efficiency enormously. Seminars and training programmes can be run from laboratories of Centres plugged into the network without having to move experts around. Several hundred technicians or conference participants can be reached by an expert presenter without having to move from country-to-country or laboratory-to-laboratory. The same goes for technical demonstrations of given technologies or repair and maintenance programmes.

Cost-Sharing

The contributions of governments to the creation of each Centre has been discussed. But the need to run the Centres as commercial enterprises has not been stressed. Laboratories should be encouraged to develop quality products which can be marketed. The Network and Centres should develop accounts for each laboratory. Such accounts should show profits or losses depending on whether the laboratories sold information and expertise, or bought information or expertise instead. The process of mutual balancing of accounts in this way would reduce the actual payments in cash that laboratories will owe each other, etc. Government cash contributions to running the Centres and Network should be provided only in the formative years. It should stop shortly after. The methods of running the system after that have been suggested, but the details have to be worked out according to the objectives to be achieved.

Conclusion

African Governments should be encouraged to consider the idea of creating Instrumentation Centres and having them staffed with first-rate scientists, engineers and technicians. If governments should buy the idea of cooperating in a region-by-region basis on this project, preliminary studies are likely to show that networking could provide an efficient solution to the general problems of equipment acquisition, calibration, installation, repair and maintenance. The computerised information services complete with equipment type, exploitation, and repair and maintenance histories of institutions in the Network, will enhance information documentation and exchange. However, the first step is to develop and improve the telecommunication networks of individual countries. The success of networking depends to a large extent on this component.

References

Kwankam, S.Y. and Ngundam, J.M. (1984a.) Information Technology and Networking : A Potential Boon to Engineering Education in Developing Countries. SEFI Annual Conference, University of Erlangen - Nurnberg, August 28 - 30.

Kwankam, S. Y. and Ngundam, J.M. (1984b). *A Model for Equipment Maintenance and Repair in Suboptimal Environments : Part I Maintainability.* ANSTI-EE '84, Nairobi, November 5-7.

Nawaz Sharif, M and Haq, A.K.M (1980). A Time-level Model of Technology Transfer *IEEE Transactions on Engineering Management,* Vol.Em-27, No. 2.

UNIDO, *Information Systems for Training Needs and Opportunities in Developing Countries* CRP 15, Training Branch.

*This paper was not presented at the Workshop, but the Organisers recognise its importance and have therefore included it in these Proceedings.

GENERAL DISCUSSION ON NETWORKING OF INSTRUMENTATION CENTRES

Discussant Panel:	A. Menyhard	–	IFC, Hungary
	H. L. Songolo	–	Zambia

Menyhard, *Hungary*: Funding for an Instrumentation Centre can come from markets, governments, and donor agencies. Instrumentation R&M must be in the budget, and not hidden.

One cannot put everything into an IC — it becomes too broad. Handle the instrumentation and supervise the IC in an institutional way. Networking can only work when it is based in a working institution.

Songolo, *Zambia*: NUSESA is not an amateur organisation, but a professional working programme. Funding should be considered carefully. For consultancies, the technicians should gain more. I suggest that there be five Centres (N. Africa, E. Africa. S. Africa, W. Africa and Central Africa), rather than having two Centres in West Africa.

Taylor, *Vienna*: ANSTI started a network in 1985 which is now apparently dead, i.e., NICA (Network of Instrumentation Centres in Africa).

Kwankam, *Cameroon*: ANSTI was a star connected network — a network of networks (10 sub-networks on specific disciplines). WHO conceived of a network called the Global Action Plan on Health Care Equipment. Documents are available. The proposed task force needs specific guidelines to follow.

Lelei, *Kenya*: Maintenance of a number of medical equipment in Kenya is supported by Austria and GTZ.

Gurkok, *Vienna*: There are apparently many existing Centres — but why is there no information about them? Possibly because they are regional, e.g., NUSESA aimed at SADCC countries.

Manyala, *Kenya*: The steps to realise the Network are through conducting Workshops, or considering the recommendations of a committee and to recognise efforts already put by the some of the international organisations like IAEA, etc.

Nyambala, *Kenya*: We need to form a task force with composition consisting of regional representatives, special agencies (UNESCO, UNIDO, IAEA, etc.), and co-opted members (e.g., institutions like ICIPE, etc.). The Task Force Project should be funded by agencies like UNDP, UNIDO, and UNESCO.

The terms of reference of the Task Force should include

- Study of existing networks in Africa and other places
- Study of capabilities of ICs in regions to avoid duplication in order to form a framework for collaboration
- Drawing up of recommendations, e.g., the operational framework: board, committees
- Financial arrangements
- Actual launching of Network
- Development plan (how to proceed)
- Time span allowed, e.g., 6 months

Namukolo, *Zambia*: Another existing network, NIN (Nuclear Instrumentation Networks in Africa) exists. The member countries are Zambia, Egypt, and Ghana.

Gardos, *Vienna*: The IAEA conducts training courses of 3–6 weeks at sub-regional level for group fellowship training at Vienna, and in electronics and on-the job training and assists Centres in spare parts supply.

Mzengeza, *Zimbabwe*: There is another network of veterinary schools and centres for repair of equipment.

CHAIRMAN'S SUMMARY

- There is a need for networking in Africa - and a need to establish reasons for the non-effectiveness of existing networks.
- A Task Force is necessary to (i) study existing networks, (ii) study capabilities of institutions, and (iii) recommend a plan of action.
- Training of managers is another necessity.
- The lack of communication between individual institutions and co-ordination between donors should be addressed.

CLOSING REMARKS

CLOSING REMARKS

P.O. Okaka

Workshop Chairman
Director of Technical Training
Ministry of Technical Training and
Applied Technology
Nairobi, Kenya

Distinguished participants, it is not normal for me to speak at the end of a long day like this, but I think with the good work that has been done and the honour that has been bestowed upon me to chair this meeting of dignitaries of your calibre, I would like to say a few words.

First and foremost, and this is very important, this Workshop has the strong support of the Kenya Government. I am now wearing two hats: I am wearing the hat of the Chairman of the closing session, but my Minister has delegated the duty to me to report the findings of this Workshop to the Kenya Government. Of course, the Kenya Government was represented earlier during the official opening by the Permanent Secretary, on behalf of the Minister. All of the discussions that have taken place have been constructive, sincere, profitable, professional and in a friendly atmosphere of brotherhood. Although the discussions were sometimes heated, I never saw anybody not smiling at the end of any argument. All the objectives of the Workshop were met within the time set.

However, there was an underlying and significant common denominator. It was sentimental; we were informed of various networks which have become victims of a very high child mortality. Oftentimes we speak of "brain drain", but this is a typical case of "a brain in the drain", because we have spent a lot of time, and a lot of energy in creating a network, but then it ends up in the drain after two years or so. I hope that we are tired of funerals, and today's meeting will not be one that we shall start again — building structures for only more disappointment.

I hope that those of you who have been given responsibilities will do so in the name of professionalism. Actually, if you look at the quality of papers that the participants have presented and you listen to the discussions that took place, I sometimes wonder whether we do not have some of the highest-calibre human resources in the world. But there is a block between that human resource and profitability. I am appealing to you all, that whatever we have done today, whatever we have said and whatever structures we have set up, let us not create a situation such that our brains are again going to be in the drain. If whatever we have done ends up in nothing, it is like spending a lot of energy digging a hole and again filling it up.

Before I finish, I would like to thank again the Kenya Government, UNDP and ICIPE for their very outstanding hospitality. Something else happens at the end of such workshops or conferences: people meet the greatest objective by knowing each other. We have now got some invaluable contacts with technocrats, professionals and others in various human endeavors. Even if we cannot meet personally, let us just write to each other, and communicate so that again the efforts we have made here do not end up in the drain.

Professor Kwankam from the University of Yaounde would like to add a further note of thanks.

"Thank you, Mr. Chairman, for this opportunity. I think, as the Chairman has said, that this has been one of the really fruitful get-togethers and I wholeheartedly agree with the last point he made that one of the major benefits from any kind of gathering of this sort is the human contact. Starting with the person to my left, I have already obtained many addresses from him and my word processor will be very busy as soon as I get back home. So I wholeheartedly subscribe to the idea of our remaining in contact and essentially starting this Network. It will start as a Network of individuals and later on grow to a Network of institutions. I think the Network has been launched at this meeting, and for that fact as well as for the experience of participating in this Workshop, I think all the participants will join me in thanking, not in any particular order of merit, the ICIPE, represented here by Mr. Mando, for the marvelous organisation, thanking the Chair, and all the individuals who have sat in the Chair, and for the marvelous way in which they have conducted this Workshop. We thank all the support staff from the travel people to those in the Instrumentation Unit of the ICIPE. I wish on behalf of all the participants then, to thank all these people and say congratulations for a good job well done! Thank you Mr. Chairman".

Thank you very much, Professor Kwankam. As a final point,I think the Proceedings and the details of anything that follows a Workshop like this will be communicated to you as soon as they have been finalised. Thank you very much Ladies and Gentlemen.

OBSERVATIONS AND RECOMMENDATIONS

Preamble

1. The slow rate of assimilating new technologies, and improper or lack of maintenance of scientific instruments and equipment have long been recognised as major contributors to the retarded growth in research and development (R&D) in Africa, particularly in sub-Saharan Africa. Once acquired, scientific instruments and equipment rapidly fall into disuse and wastage because of various reasons: improper choice/use/purchase; lack of maintenance management; lack of technical expertise for effective repair and maintenance; lack of clear supportive policies; and finally, unavailability of spare parts. The net result is reduced R&D output and wastage of scarce foreign exchange.

2. The rapid technological advance that has taken place in the last two decades has brought into sharp focus the problem of inadequate maintenance and servicing of scientific instruments and equipment. Instrumentation technology is in a constant state of flux: new instruments and equipment appear in the market in quick succession, and the rate of obsolescence is high. This, in turn, places special demands on users, maintenance engineers and technicians; they must develop appropriate skills and constantly upgrade them to keep abreast of new technological advances.

3. It is with realisation of the fact that progress in science and technology, and specifically the pace and quality of research and development, is largely dependent on the availability and use of well-serviced, good-quality instrumentation, that this Workshop makes its observations and recommendations.

PROCUREMENT OF SCIENTIFIC INSTRUMENTS AND EQUIPMENT IN AFRICA

Observations

4. The Workshop participants noted that the problems of repair and maintenance of scientific instruments and equipment in Africa start

right from the procurement stage. Some of the major problems encountered at this stage are:

- poor specifications;
- lack of proper consultation both at the institutional level and between donors and end-users;
- lack of independent sources of funds to users for purchase of equipment.

5. The participants also noted that as a result of the problems mentioned in Paragraph One (1), a wide variety of equipment from diverse manufacturers has found its way into institutions in Africa, leading to various repair, maintenance, and operational problems.

6 The Workshop noted that there is the need to standardise the equipment at institutional, national and regional levels in Africa.

Recommendations

7. Technical aid agencies, governments and instrumentation centres should arrange appropriate training programmes for users, instrument engineers, and administrators in various aspects of procurement.

8. Exchange of information and experiences between users and instrumentation centres on supplier/manufacturer and equipment performance (including maintainability, availability of spares, etc.) should be promoted. This should be done through such activities as visits, workshops, seminars, exhibitions, open-days, newsletters and other publications.

9. Governments and aid agencies should strengthen the capabilities of instrumentation centres in procurement by facilitating the acquisition of journals, indexes and registers of products and manufacturers and other information sources.

REPAIR, SERVICING AND MAINTENANCE OF SCIENTIFIC INSTRUMENTS AND EQUIPMENT

Observations

10. The Workshop observed that repair and maintenance problems arise from:

- inadequate servicing facilities and equipment;
- acquisition of modern and sophisticated equipment without adequate transfer of technology;
- inadequate budgetary provisions for repair and maintenance in many African institutions;
- lack of a maintenance culture;
- deficiencies in human resources.

11. The Workshop noted that the following should be considered in order to alleviate repair and maintenance problems:

- assessment of maintenance needs and analysis of existing problems at the planning stage, before investment;
- development and implementation of appropriate maintenance schemes;
- motivation of staff and training of both users and service personnel;
- exploration and exploitation of R&D possibilities;
- budgetary provision for repair, maintenance and equipment replacement.

Recommendations

12. The Workshop strongly recommended that new instrumentation centres be established at the institutional, national, sub-regional and regional levels, and that existing centres be vigorously supported.

13. Technical aid agencies should consider creating a flexible funding facility which will allocate annually a modest grant to be used for purchasing spare parts by each participating instrumentation service centre.

DESIGN, DEVELOPMENT, MODIFICATION, AND PRODUCTION OF SCIENTIFIC EQUIPMENT

Observations

14. The Workshop noted that many designs for equipment already exist but there are major constraints in transforming these designs into products of widespread use. These constraints include:

- lack of finance;
- prejudice against locally manufactured products;
- lack of supporting services and facilities, e.g., moulding and casting facilities;
- lack of an enabling environment for maximum exploitation of available human resources;
- insufficient numbers of entrepreneurs and lack of support for the few that are available;
- lack of an institutional framework for the promotion of interaction amongst the designers, entrepreneurs, and financiers.

15. The meeting noted that insufficient or lack of documentation on design and modification of equipment is a constraint to the development and production of scientific equipment.

16. It was also noted that there is inadequate identification of markets and marketable products.

Recommendations

17. Aid agencies, national governments and institutions should be sensitised to support product development and production. UNIDO and other agencies should play a catalytic role in this process.

18. The meeting strongly recommended that enterpreneurship should be supported through venture capital which can be provided through governmental, non-governmental, and donor agency funding.

INSTRUMENTATION CENTRES AND NETWORKING

Observations

19. The Workshop noted the existence of instrumentation centres in Africa dedicated to various functions.

20. The Workshop further observed that instrumentation centres are the most appropriate approach to maintenance problems, and to the proper management of instrument services.

21. The Workshop observed that there are a number of networks dedicated to specific end-users in Africa.

22. The Workshop further observed that there is a need for the creation of an effective and sustainable network of instrumentation centres in Africa.

Recommendations

23. The Workshop strongly recommended the establishment of new instrumentation centres at institutional, national, sub-regional and regional levels and encouraged support for existing centres.

24. It was further recommended that funding for the instrumentation centres be initially sought from technical aid agencies, governments and the institutions themselves, but with the subsequent aim of being self-financing.

25. The Workshop recommended the creation of an effective and sustainable network of instrumentation centres in Africa.

26. The Workshop further recommended that, as a first step towards the creation of the network of instrumentation centres, a Task Force be formed with the following terms of reference:

- carry out a study of the existing networks with a view to establishing their current functional state;
- carry out an assessment of the capabilities of the existing instrumentation centres and institutions;
- propose practical frameworks for the creation and operation of the network.

27. The Workshop recommended that:

- the Task Force should comprise representatives from UNDP, IAEA, UNIDO, UNESCO, ICIPE, CAPA and one representative each from North Africa, West Africa, Central Africa, Eastern Africa and Southern Africa;
- the Task Force should complete its assignment within twelve (12) months;
- the findings of the Task Force should be presented and discussed in a follow-up workshop to be organised by the ICIPE;
- for matters relating to the funding of the Task Force and the follow-up Workshop, the ICIPE is mandated to approach UNDP.

ANNEX 1

WORKSHOP PROGRAMME

WORKSHOP CHAIRMAN:
Mr. P.O. Okaka
Director of Technical Training, Ministry of Technical Training and Applied Technology
Kenya

Sunday, 24th November 1991

All Day	Arrival of Participants in Nairobi
1800 - 2000 Hours	Official Openjng of the Workshop
	CHIEF GUEST: Hon. Prof. S.K. Ongeri, M.P. Minister for Technical Training and Applied Technology, Kenya
	Opening Address Minister's speech read by Prof. Karega Mutahi, Permanent Secretary in the Ministry
	Reception (Carol Wilson Courtyard)

Monday, 25th November 1991

0830 - 0900 Hours	Registration of Participants
	INAUGURAL SESSION
0900 - 0915	WELCOMING REMARKS Prof. Thomas R. Odhiambo Director of ICIPE
	KEYNOTE ADDRESSES
0915 - 0930	Dr. A. Abdinaser Specialist in Technological Training and Research UNESCO Regional Office for Science and Technology in Africa (ROSTA) Nairobi, Kenya

0930 - 0945	Dr. G. Nderitu Director Kenya Agricultural Research Institute (KARI) Nairobi, Kenya
	Speech read by Dr. A.M. Kilewe
0945 - 1000	Dr. L. H. Dirickson Assistant to the Director Mechanical and Electrical Division Institute for Technological Research Sao Paulo, Brazil
1010 - 1010	GROUP PHOTOGRAPH
1010 - 1030	TEA/COFFEE BREAK
1030 - 1230	TOUR OF ICIPE FACILITIES
1230 - 1400	LUNCH
	SESSION I
THEME:	**PROCUREMENT OF SCIENTIFIC EQUIPMENT IN AFRICA**
	CHAIRMAN: Mr. P.O. Okaka Director of Technical Training Ministry of Technical Training and Applied Technology Kenya
1400 - 1420	Procurement of Scientific Equipment in Africa
	Dr. Eng. W.H. Tadros National Research Centre Cairo, Egypt
1420 - 1430	DISCUSSION
1430 - 1450	ICIPE's Experience in Procurement of Scientific Equipment
	Mr. J.O. Konyino Head, Instrumentation Section ICIPE
1450 - 1500	DISCUSSION
1500 - 1530	TEA/COFFEE BREAK

1530 - 1700 GENERAL DISCUSSION:

DISCUSSANT PANEL:

Dr. A. Abdinaser
Specialist in Technological Training and Research
UNESCO Regional Office for Science
and Technology in Africa (ROSTA)
Nairobi, Kenya

Dr. J.M. Ngundam
Automation and Control Laboratory
Electrical Engineering Department
Ecole Polytechnique
Yaounde, Cameroon

Mr. Ali Ahmed Djama
Institut Superieur d' Etudes et de Recherche
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Tuesday, 26th November 1991

SESSION II

THEME: **REPAIR AND MAINTENANCE OF SCIENTIFIC EQUIPMENT**

CHAIRMAN: Mr. C. Gurkok
Industrial Development Officer
UNIDO
Vienna, Austria

0830 -0850 Maintenance of Scientific Equipment:
Experiences of the Scientific Instrumentation Laboratory (LIS) of the National Research Centre (CNR) of Morocco

Prof. M. Lakhloufi
Head,
Scientific Instrumentation
Laboratory (LIS)
National Research Centre of Morocco
Rabat, Morocco

0850 - 0900 DISCUSSION

0900 - 0920 The State of Calibration Services in Kenya

Mr. J.O. Manyala
Senior Metrology Officer
Kenya Bureau of Standards
Nairobi, Kenya

0920 - 0930	DISCUSSION
0930 - 0950	Maintenance of Scientific Equipment at the International Laboratory for Research on Animal Diseases (ILRAD) Mr. M.A. Lobo Electronics Engineer ILRAD Nairobi, Kenya
0950 - 1000	DISCUSSION
1000 - 1030	TEA/COFFEE BREAK
1030 - 1230	GENERAL DISCUSSION **DISCUSSANT PANEL:** Mr. M. Gardos International Atomic Energy Agency (IAEA) Vienna, Austria Mr. Hamdy Elakkad Jeol Service Bureau Cairo, Egypt Mr. R.O. Aba National Horticultural Research Institute Ibadan, Nigeria
1230 - 1400	LUNCH **SESSION III**
THEME:	**DESIGN, DEVELOPMENT AND MODIFICATION OF SCIENTIFIC EQUIPMENT** CHAIRMAN: Mr. C. Gurkok Industrial Development Officer UNIDO Vienna, Austria
1400 - 1420	The Need for Design and Development in Africa Mr. N.O. Akonde Head Telecommunication Section Electrical and Electronic Department Kenya Polytechnic Nairobi, Kenya
1420 - 1430	DISCUSSION

1430 - 1450	Design, Development and Modification of Scientific Equipment: The Zambian Experience Mr. J.K. Namukolo National Council for Scientific Research Lusaka, Zambia
1450 - 1500	DISCUSSION
1500 - 1530	TEA/COFFEE BREAK
1530 - 1700	GENERAL DISCUSSION **DISCUSSANT PANEL:** Mr. J. Barankewitz International Service Support Manager Sartorius AG Gottingen, Germany Mr. G.S. Oyuga Electronics Engineer Kenya Industrial Research and Development Institute (KIRDI) Nairobi, Kenya

Wednesday, 27th November 1991

	SESSION IV
THEME:	**INSTRUMENTATION CENTRES**
	CHAIRMAN: P.O. Okaka Director of Technical Training Ministry of Technical Training and Applied Technology Kenya
0830 - 0850	Training in the Maintenance and Calibration of Optical and Electronic Instruments Mr. L.Y. Zinyemba Head of Engineering Regional Centre for Services in Surveying Mapping and Remote Sensing Nairobi, Kenya
0850 - 0900	DISCUSSION
0900 - 0920	Establishment of Instrumentation Centres Mr. Philip Mandalazi Head of Biochemistry and Toxicology Central Veterinary Laboratory Lilongwe, Malawi

0920 - 0930	DISCUSSION
0930 - 0950	The Establishment of an Instrumentation Unit: Nigerian Experience Mr. J.A. Obasogie Instrumentation Technologist Nigerian Institute for Oil Palm Research Benin City, Nigeria
0950 - 1000	DISCUSSION
1000 - 1030	TEA/COFFEE BREAK
1030 - 1230	GENERAL DISCUSSION **DISCUSSANT PANEL:** Mr. A. Menyhard Project Manager Instruments and Measuring Techniques Service Hungarian Academy of Sciences Budapest, Hungary Dr. A. Abdinaser Specialist in Technological Training and Research UNESCO Regional Office for Science and Technology in Africa (ROSTA) Nairobi, Kenya
1230 - 1400	LUNCH
	SESSION V
THEME:	**NETWORKING OF INSTRUMENTATION CENTRES**
	CHAIRMAN: Mr. C. Gurkok Industrial Development Officer UNIDO Vienna, Austria
1400 - 1420	The Role of Networks for Users of Scientific Equipment in the Advancement of Research and Development in Sub-Saharan Africa Mr. M.M. Lung'wecha President, NUSESA (Tanzania) Morogoro, Tanzania
1420 - 1430	DISCUSSION
1430 - 1450	Networking of Instrumentation Centres in Africa

	Dr. O.G. Oguntoyinbo Principal Institute of Agricultural Research and Training Ibadan, Nigeria
1450 - 1500	DISCUSSION
1500 - 1530	TEA/COFFEE BREAK
1530 - 1700	GENERAL DISCUSSION
	DISCUSSANT PANEL:
	Mr. A. Menyhard Project Manager Instruments and Measuring Techniques Service of the Hungarian Academy of Sciences Budapest, Hungary
	Mr. H. Songolo Soil Science Department The University of Zambia Lusaka, Zambia

Thursday, 28th November 1991

0830 - 1230	Meeting of Working Group to Draft a Report on Observations and Recommendations
	Optional visit to two research institutions:
	• International Laboratory for Research on Animal Diseases (ILRAD), Nairobi
	• Institute of Primate Research National Museums of Kenya, Nairobi
1230 - 1400	LUNCH
1400 - 1500	Meeting of Working Group continues
1500 - 1530	TEA/COFFEE BREAK
1530 - 1700	Report by Working Group Chairman Mr. C. Gurkok, UNIDO, Vienna
	Discussions and Adoption of the Working Group Report
1700 - 1715	CLOSING REMARKS by Workshop Chairman
1930	CLOSING DINNER at Carnivore Restaurant, Nairobi

ANNEX 2

LIST OF PARTICIPANTS

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Dr. J.M. Ngundam	Member
Prof. M. Lakloufi	Member
Dr. O.G. Oguntoyinbo	Member
Dr. L.H. Dirickson	Member
Mr. H.L. Songolo	Member
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Mr. J.R. Kapkirwok	Rapporteur
Mr. J.O. Konyino	Rapporteur
Mr. J. Alwala	Rapporteur
Mr. A. Mando	Workshop Coordinator

"The dependence of R&D work on complex and expensive instrumentation is immense. The effect of this dependence has been to inhibit the role of developing nations (especially African countries) in the advancement and exploitation of various technical achievements made in the developed countries. One major reason for the technological gap between developed and developing countries is the lack of skilled technical personnel to maintain and repair scientific instruments".

P. Mandalazi, Central Veterinary Laboratory, Chilongwe, Malawi.

"About 35% of the equipment in the SADCC country institutions are defective, hence making it difficult for scientists to conduct research effectively."

Dr. Lennart Prage, Representative of International Foundation of Science.

"Metrology infrastructure and facilities are barely developed in the African region. Out of 23 ARSO member states, only three countries can be said to have comprehensive facilities and active implementation of legal and industrial metrology work. Work in the field of scientific metrology is carried out in only one member state".

Africa Regional Organization for Standardization (ARSO).

What is desperately required today in Africa is to construct a new culture of the repair and servicing of scientific equipment, and of the maintenance and reconstruction of every important item of such equipment. The goal is to have any vital instrument perform as effectively as its own specification limits determine, for it to have a long functional life, and for it to be a true friend of the scientist, the educationist, and the practitioner.

Prof. Thomas R. Odhiambo, Director, ICIPE, Kenya.

"The continuous development of industry needs an effective operational background for the instrumentation which serves all fields of the economy; this background can be implemented and effectively managed by an Instrumentation Service Centre.

A. Menyhard, Instrument & Measuring Techniques Services,
Hungarian Academy of Sciences, Budapest .

"Most African governments have allocated a large proportion of their budgets for the education of their people. Many engineers and scientists have been trained, but their work has been hampered by lack of proper exposure and access to modern equipment. This nightmare is further deepened by the [large] variety of models of equipment and instruments that have been acquired through donations or through direct purchase schemes... Africa must therefore with urgency, build her own indigenous technological capacity to solve her problems in a sustainable way. We cannot forever continue looking to the developed world to solve our problems.

Hon. Prof. S.K. Ongeri, Minister for Technical Training and Applied Technology, Kenya.

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