UNIVERSITY OF PORT HARCOURT.

MEASURING THE MEASURABLES AND UNMEASURABLES: A PRECURSOR FOR NATIONAL DEVELOPMENT.

The 72nd Inaugural Lecture

By

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DEDICATION.

This work is dedicated to the following; Comfort Nwauju, Samuel Amedo, Gidoen E-emi, Miimi Nyimenka, Joshua Chichiiya Olesande, Edith Lale, Grace Neene Ochure, Israel Nyimentito and Immanuela Kasemi for providing obedience, support and stability of mind/soul during the course of my academic pilgrimage.

And

Late Dr. Samuel Chichii Owate (of Blessed memory; The Architect of my Educational pursuit).

ACKNOWLEDGEMENTS

We sincerely appreciate and acknowledge the inputs of Chief C.I. Abraham; my former Principal , Okrika Grammar School, Professors A. Evwaraye, Charles Ofoegbu and Joshua, my supervisors and lecturers, Dr A. Coker, Former Director General SHEDA, Abuja and others (who due to space could not be mentioned here) that had great impact on my academic and spiritual development. Mrs Helen Okparanji, your good typing reduced my stress, Dr P.C Nmon, you are indeed my friends who took this work as yours, Mr Ben Otokunefor, Thank you for involving your super skill in computing to format and standardizing the work. Also I must not fail to thank my good friend and Guardian, Prof. J.O. Ebeniro who kindly accepted to host this grand Lecture.

This section will not be complete without mentioning the inspirations and knowledge derived from the works of well known Scientists like Albert Einstein (1905), Lord Kelvin, Galileo Galilei, IMEKO, Isaac Newton (1687), Charles Darwin (1859), Johannes Kepler(laws of Planetary motion), Louis Pasteur (works on Polarized light), James Maxwell, Edwin Hubble, Paul Dirac, Lord Archimedes, Marie Curie, William Thompson, James Prescott Joule, Henry Bessemer, Robert Boyle, Blaise Pascal, Nikola Tesh, Thomas Alva Edison, Niels Bohur, Alexander Graham Bell, Ernest Rutherford, Aristotle whose first works include Physics and Meta Physics, Alfred Nobel who singularly established the Fund for the NOBEL PRICE just to mention but a few.

MEASURING THE MEASURABLES AND UNMEASURABLES: A PRECURSOR FOR NATIONAL DEVELOPMENT.

1.0 PREAMBLES TO MEASUREMENT SYSTEMS

Every Scientist, Engineer, Technician and in fact Technologist know only a little about the answer to the question, "What is measurement Science". However, only a few people have gone beyond the boundaries of their own specialized fields and applications in terms of defining it. This is because measurement Science is as old as the earth. Men are born into it and at early age begin to perform one kind of measurement or the other without bothering about its meaning or definition. Measurement science can be seen as a towering achievement of the human intellect in its quest to understanding the world and ourselves. Measurement can be defined briefly as the Science of allocating numerical data to the characteristics properties of objects, events, quantities and systems observed under well-known conditions in order to precisely describe a particular system, object or event. It is essentially, an empirical but most objective form of the fundamentals of science, engineering and related subjects. ***Galileo Galilei once said "count what is countable; measure what is measurable, and what is not measurable make measurable".***

Measurement is the essential links between science, mathematics and the development of a society in the sense that it supplies the numbers with which the applied scientists and engineers use in checking, clarifying and redefining their mathematical concepts as well as models of events, systems and objects to suit a prevailing and expected observations. The basic importance of such a link was underlined by Lord Kelvin who said that "I often say that when you can measure what you are speaking about, and express it in numerical form, you know something about it. But when you cannot express it in numbers then your knowledge about it is meager and unsatisfactory, it may be the beginning of knowledge but you have scarcely, in your thoughts, advanced to the stage of science whatever the matter may be". This means that ideas and concepts are relatively clearer if expressed within the numerical frame of format. Measurement science attempts to observe the phenomena of nature and tries to find patterns and principles that relate these phenomena. These patterns are further translated to theories and when they are very well established and of broad usage become laws or principles. Note that theories are collections of random thoughts or unproven concepts. They are logical explanation of natural phenomena based upon observations and biological evolutions. However laws of physics are tested and proven facts that have withstood the test of time over a long period of times. For example the universal laws of gravitational pull or attraction and that of inertia (motion) have existed with us.

The increasing introduction of more modern automatic systems into the manufacturing, oil and petrochemical industries within the last three decades and the common automatic control-systems of industrial chemical processes has in effect increased the need to perform a more accurate but precise measurements of the required parameters.

Also, the development of microprocessors, micro and mini computers has in part equally contributed to the reduction of associated problems that additional measurement requirements had created. Some of the instruments have in themselves increased the complexity of achieving reliably data without the use of technically qualified or trained staff. It is of utmost importance that once a decision has been reached to acquire a more advanced measurement technique (such as computers, microprocessors or complex instruments) to handle tasks previously performed manually; a technically qualified staff has to be employed. The above condition is necessary because measurements are subject to variety of error components which are either deterministic or probabilistic. Thus, all measurements should be critically analyzed and determined before the data is regarded as being acceptable

2.0 HISTORY OF MEASUREMENT SCIENCE

Mr. Vice Chancellor Sir, please permit me to state in strong terms that the concept of Science of measurement is both ancient and modern. Ancient in the sense that knowingly or not, man has employed the principles and techniques of measurements from his early days (Early man). For example, the early man was pre-occupied with the predictions of sunset, winter, summer, and rainy, planting and harvesting seasons. These were assumed to be important for ensuring proper crop planting and climatic warning. Astrologists and Navigators also applied the use of stars and other heavenly bodies in predicting directions and events and these are further examples of ancient practice of modern measurement science.

In recent times, there has been a strong move to transform what every Physical Scientist, Engineer and a good number of other professionals have for long, taken for granted into an organized systematic model subject- discipline. This has being with great regard to the fact that this subject had been part and parcel of the scientific and technological arts and craft. This move gave birth to measurement science as a discipline and a department at Manchester University of Science and Technology, England. It is a specialist subject having its own package of knowledge and characteristic. Thus, within the last two decades, this set of knowledge has been redefined and in fact became thoroughly refined. Consequently, there is relatively little dissension on what the finer details should be. The subject ethical code of conduct and its content are being reviewed by experts at the University of Manchester Institute of Science and Technology (UMIST) and City University in England. With these noble developments, measurement science has come to stay and is being taught worldwide with department of Physics, UNIPORT not left out.

Between 1824 and 1907 William Thomson invented and applied some of his instruments for measurements of physical quantities such as length, mass and time in a construction company. Many people did initially not take him serious but after the success, his views became highly rated. However, the initial failures of some of his projects did not discourage him but later led to a more careful consideration of what measurement is all about.

Thomson's principles and views of many other scientists have challenged a number of other professionals and there are a number of other world-wide moves to ensure that measurement science is properly appreciated and honoured. The works of the international measurement confederation (IMEKO) and particularly that of the committee on higher education in England made science instruments and the formation of a new specialized department of instrumentation and Analytical Science at UMIST well pronounced and have greatly contributed to the advancement of measurement science and instrumentation. It is expected that before the end of this generation measurement science must have developed to an advanced stage thereby improving further the development of Technology.

3.0 SYSTEM OF UNITS AND PHYSICAL QUANTITIES.

Physical quantities are the building blocks of the laws and hypothesis of physics. There are three quantities which are usually expressed in terms of well defined system of units. They are commonly used in science, technology and engineering applications. These are the MKS, CGS and FPS Systems. The MKS System measures mass in kilogram, length in meter and time in second, while the CGS System adopts the system of taking length measurement in centimeter, mass in grams and time in second, whereas the FPS system is the old British foot-pound –second system.

Generally, the International System of units commonly called SI unit or "System International" is the most widely accepted system of unit for mechanical, thermodynamic, electric and optical measurements among others. The SI Unit is based on six fundamental units: meter for length, second for time the kilogram for mass, Kelvin for temperature, ampere for electric current and the Candela for luminosity of light source.

3.1 FUNDAMENTAL AND DERIVED UNITS

Physical quantities are arbitrary divided into two different units, the fundamental and derived units. Fundamental physical units are those quantities whose defining operation does not depend upon any other known physical quantity. Examples are time, length and mass. In contrast, DERIVED physical units are the quantities whose defining operations are based upon other physical quantities e.g. density, acceleration and velocity. In fact, length, time and mass are regarded as fundamental units because they are regarded as foundation units of the metric system upon which some other units derive their basic definitions. On the other hand, derived unit are constructed by a combination of some of the fundamental units. In recent times the fundamental units have been partly expanded to include Kelvin for temperature, ampere for electric current and candela for luminosity of light source. These three units are in most cases regarded by scholars as "redundant fundamental physical quantities." This is because they are not REAL fundamental units since they can be measured with suitable combinations of either the meters, second or kilograms. For example temperature is a measure of the degree of hotness of a body which is a length gradient type of measurement. However, for practical reason, it is more convenient to make up independent units for these quantities. It should be understood that they are not pure fundamental units.

3.2 DIMENSIONS OF UNITS.

The dimension of a particular system of unit expresses the derived form in terms of the three fundamental units. But can all physical quantities be expressed in terms of only length (L), time (T) and mass (M)? The answer is YES. They all can be given such derived units, but sometimes it is very awkward to do that for some quantities and that is why some quantities are given special names. For example the units for electric charge is dimensionally defined as $\{(Kg)^{½}(m)^{3/2}/s\}$. In practice this unit cannot lend itself to producing experimental data hence called Coulomb.

In typical dimensional expressions, length is expressed by L, mass by M and time T. In other words

Length	=	L
Mass	=	M
Time	=	T

With these symbols we can derive the typical expression for density (R) as;

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} = \frac{M}{L^3} = \frac{Kg}{m^3}$$

4.0 PRINCIPLES OF MEASUREMENT SYSTEM

It is essential in measurement to understand:

i. The physical and chemical nature of the measurement system;
ii. Error propagation and its environment (conditions);
iii. Effects of noise and other external influences;
iv. The influence of (i) and (ii) upon the results obtained.

In gaining this understanding, it may be necessary to plan a series of preliminary measurement experiments. The legend, Galileo Galilei studied falling bodies by dropping them from the leaning Tower in Pisa, Italy and equally investigated the motion of a pendulum by observing the swinging of the Chandelier in an adjacent Cathedral. Hubble Space Telescope is the first major telescope to operate outside the earth's atmosphere. Measurements made with this telescope have helped determine the age and expansion rate of the universe.

Each of such experiment should aim at providing the measurement scientist with specific understanding of particular parts of the entire system. In planning, this part of series of measurements, it is a common practice in advanced industries to invite the help of experienced statisticians, but are they knowledgeable on the subject? A good professional should be capable of assisting in the planning of the measurements system. A good measurements system is one that is accurate and free from bias. The data derived or measured is accurate if the expected value of measurement is equal to the bias value. This is irrespective of any systematic or random errors.

4.1 ESSENTIALS OF MEASUREMENT

The process of measurement is usually described in terms of a block diagram shown in the Fig. 1 below:

The different stages presented are as follows:

i. The sensing process;

ii. The transduction process (when separated from sensor);

iii. Data transmission
Data reduction or manipulation
Data display
Data conversion
Data storage

iv Feedback to either the process for control purpose or to the sensor and transducer for reasons such as overall stability, improvement and sensitivity increases.

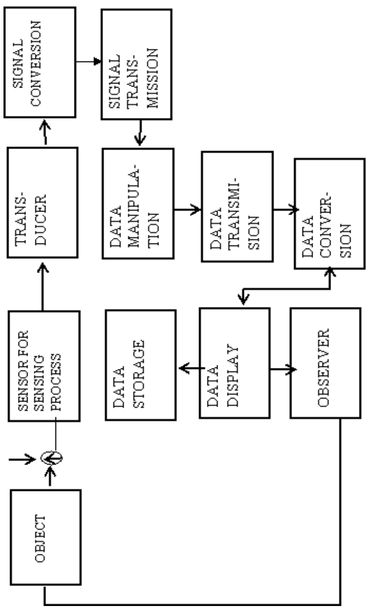

Fig. 1: Essentials of measurement system

The measurement treated so far is known as the empirical technique. This type of analytic measurement employs instrumentation and is empirical in nature. They involve the use of arbitrary "Signals" recorded instrumentally and it is necessary under such circumstances to relate the observed signal to that produced by a known standard.

4.2 PERFORMANCE CHARACTERISTICS OF MEASUREMENT DEVICES

The function of any measuring device is to sense or detect parameters encountered in the system. Such parameters like pressure, temperature, resistance, voltages, current and powers changes can be accessed through linear dimensional changes and motions. The measuring instrument should be capable of accurately detecting the changes that occur. This means that for optimum performance; a number of basic characteristics are usually considered.

The performance characteristics are described in two stages. The static (excitation stage) and dynamic variables. The dynamic relations between the instrument input and output are generally defined by the use of differential equations. The following terms are considered as static variables. This includes but not limited to accuracy, resolution, sensitivity, repeatability, drifts errors, linearity, non-linearity, dead band, backlash, hysteresis and zero stability. It must be stressed that the overall performance of any measurement system is primarily determined by its static and dynamic characteristic.

Accuracy: This is a quantitative term that defines the relative closeness of the instrument output to the true or an accepted standard value of the measure and with specified probability limits. It is usually specified with an in-accuracy (uncertainty). This is normally the sum of the contributions from uncertainties. Factors such as non-linearity and drifts contribute it. An absolute accuracy has no significance in any measurement system because in most experiments, accuracy is influenced by limits of intrinsic errors arising from instabilities of the electrical zero and environmental condition of the instrument. Obtained results are usually expressed with a plus or minus sign indicating the uncertainty limit. This is determined by a standard calibration curve under specified operating conditions with the results so obtained, viewed with some level of confidence.

Precision: It is important not to confuse the terms "Precision" and "Accuracy" in consideration of measurement systems. As defined above, accuracy must be used in relation to the definition of possible systematic error, whereas "Precision" is applied in relation to the random errors in the system. It should be stressed that under random error condition, the normal law for errors could be applied. This predicts the Gaussian distribution frequency of occurrence of the observations. The relative standard deviation in a series of measurement is used to evaluate the magnitude of the random errors. Precision is then defined as the closeness with which individual measurements could be distributed about the mean values. In this case, it refers to the level of agreement of the set of data among themselves. Precision has no guarantee of accuracy. It is an accuracy issued without regard to the possible systematic error. Whereas, precision is applied in relation to the random errors within measurement system, the relative standard deviation in a series of measurement is used to evaluate the magnitude of the random error observed.

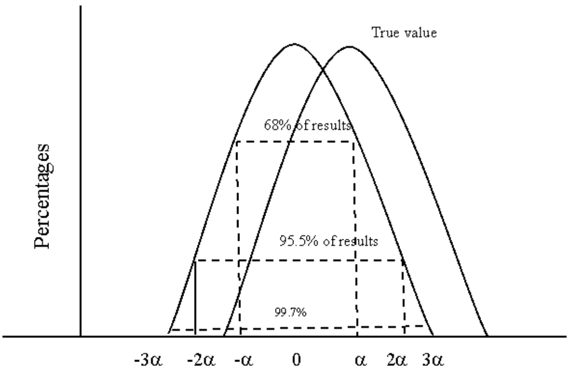

Fig. 2: Typical precision measurement

As showed in the Figure 2, above, it is impossible to have measurement at high precision which are inaccurate when the precision is low. However accurate measurements are difficult to obtain. Most observations fall within the -3α and +3α standard deviation units of the mean condition limit.

5.0 APPLICATION OF MEASUREMENT INSTRUMENTATION SYSTEM

Engineers, Scientists, Technologists and Technicians are always involved with measurements in terms of volts, amperes, ohms, watts and many other parameters. Most often than not, they are faced with an ever increasing variety of instruments. They range from a simple pointer instrument such as ammeter to complex computer-controlled systems. Therefore, it may be useful if the user of any instrument understands the basic operation principles of the measurement device. There are different applications of measurement instruments and device characteristics. They may be functionally grouped into three application zones and these classifications are based upon the operational functions of the device. They include process monitoring, control and measurement of process parameters and data/experimental analysis of the system.

5.1 PROCESS MONITORING

These are classes of measuring instrument and devices that essentially perform the functions of monitoring the system under observations. Examples include such devices like thermometers, barometers and anemometers. These instruments simply sense and present the prevailing condition of the immediate environment. This means that their readings do not serve any control purposes both in the technical and ordinary senses. Therefore such instruments like water, gas, pump and electric meters primarily monitor (check) the system. The basic purpose of monitoring instruments is to tell the observer the prevailing conditions of the system.

5.2 **PROCESS CONTROL INSTRUMENT**:

In certain applications, some instruments serve as components of an automatic control system. Such instruments are usually found within the process unit (Control rooms) of most oil refinery and petrochemical industries. A typical block diagram is presented in the Fig below.

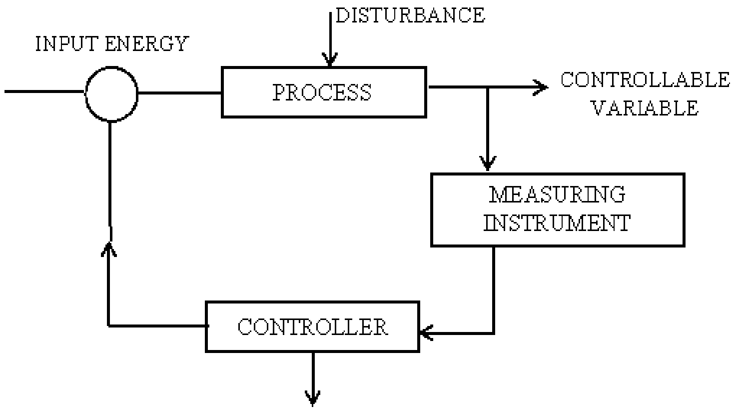

Fig. 3: A Typical process Control system

5.3 MEASURED VALUE OF VARIABLE

In order to control any variable, the parameter must be measured and compared with a chosen standard. The output is then rejected, accepted or sent back for correction in the processing unit. The above functions are easily executed through feedback principles. This is discussed in detail in most electrical/electronic books. The fact that the instrument is acting as a controller pre-supposes that it is absolutely necessary to measure the measurable variable. Thus, control system must as a necessity incorporate a measuring device before the controller. Lastly a final control element as shown in Fig. 3 is imperative. Examples of such system are home-heating devices and freezing systems with type of thermostatic control.

6 DATA AND EXPERIMENTAL ANALYSIS

Theories, data collections and experimental analysis are important steps in measurements. This is because the data presented from the measurand are usually processed by involving mathematical concepts and models. Some of these principles are usually approximated. The limitations involved in such process precisely are well established and known. For proper interpretations, the observation, theories and experiments should be complementary and good Scientists develop conceptual and logical approach to problem solving. This requires good knowledge and familiarity with the measurand and measurement system. However, statistical collation, execution and evaluation of data (results) are equally of great importance to the validity of the measurement technique and data collected. This is why known statistical model and simulation of basic theoretical approach are normally employed in the design stage of good measurement systems. This makes for less complex explanation and easy understanding of most complex concepts. This is because advanced experimental measurements apply technical expertise and the ordinarily simple concepts and models to solve complex and difficult human problems by measuring the measurable.

7 ARRANGEMENT AND FUNCTIONAL DESCRIPTION OF A TYPICAL MEASUREMENT SYSTEM

In designing a measurement instrumentation system, one should in the first place create a realistic specification of the quantities to be measured. The tolerance limit and the purpose of the data collected. These are some of the questions that should be answered at the early design stages with an attempt to provide the answers to some of these questions; it is then possible to translate the operations of the measurements system into functional element of the instruments. The performance of such a system can be defined in terms of static and dynamic characteristics. The basic arrangement of most functional elements in a typical instrument is presented in Fig. 4. They include all the primary functions considered important for a full description of any given instrumentation system.

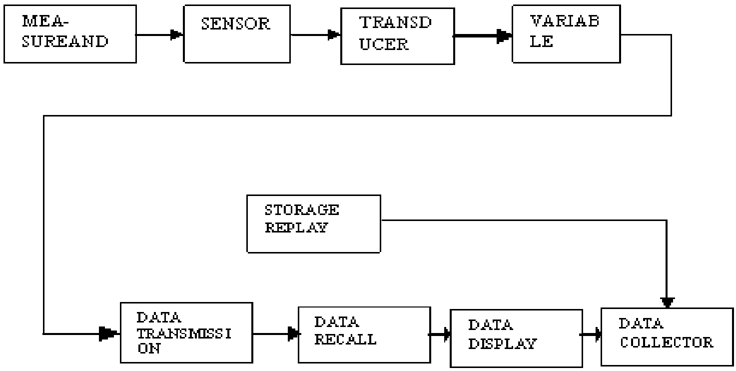

Fig.4: An open-loop measurement system.

8 BASIC OPEN-LOOP FUNCTIONAL ELEMENTS (OR IRREGULARITY OF SYSTEM OF AN INSTRUMENT SYSTEM

The basic functional elements of an instrumentation system consist of the measurands, sensors, transducers, variables, manipulation data transmission, storage/replay unit, data recall, and data display and data collector. Primarily, the sensor is that which first receives energy from the measurand (environment being sensed). It is helpful to mention that energy is usually extracted from the measurand through the mechanism of exciting it. The variable extracted may or may not be converted to an easy measurable quantity. Therefore, a variable conversion element (transducer) is in some cases incorporated. Every instrument system would not necessarily have a separate transducer, thus in some case, the transducer also act as the sensor. This does not imply that technically, the word sensor could be interchanged for transducer or vice versa. In Fig4, is shown a situation of an open-loop instrument system as applied in a typical manufacturing or process production unit. It definitely demands the immediate employment of a stationed active operator who will regularly monitor the system so as to maintain the predetermined measured value or quantity. The problem could be solved by adding a reference network of some type of comparator and a feedback network path to the basic operating system. This type of additional circulating loop converts the open-loop basic functional elements of the measurement system to a closed-loop system. A simplified diagram of the closed loop measurement system is presented.

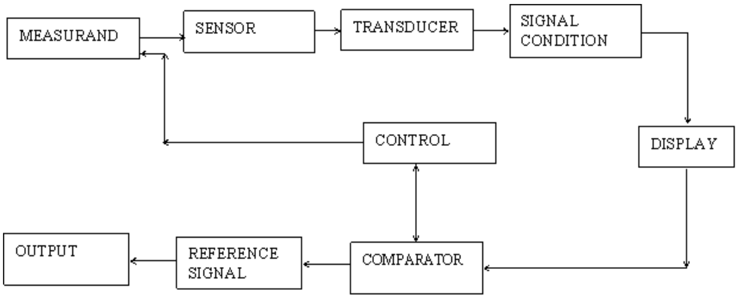

FIG. 5: CLOSED LOOP BASIC MEASUREMENT SYSTEM

The closed loop measurement system is very ideal for most instruments it measures, compares and controls the output of the system and this could easily be adopted for quality control.

9 CONCEPT OF IDEAL TERMINOLOGIES

There are certain common concepts in measurements and in particular physics that changes in meanings and could lead to misinterpretations. ***For example the difference between random and systematic errors, precision and accuracy, work and energy, temperature and heat, speed and velocity, momentum and power just to mention a few.*** The day to day interpretation of usage of the above listed words may lead to serious miss-understanding of the concepts within the scientific world. This may lead to the common deductions that Science is very difficult when compared to arts and social sciences.

10 APPLICATIONS OF MEASUREMENT SYSTEMS

10.1 POPULATION STATISTICS FROM U.S. CENSUS DEPARTMENT FOR NIGERIA

Table1 NIGERIAN DEMOGRAPHIC INDICATORS: 1998 AND 2010

	1998	2010
Births per 1,000 population	42	37
Deaths per 1,000 population	13	16
Rate of natural increase (percent)	2.9	2.1
Annual rate of growth (percent)	3.0	2.1
Life expectancy at birth (years)	53.6	46.3
Infant deaths per 1,000 live births	71	57
Total fertility rate (per woman)	6.1	5.1

Derived from MOTHERLAND NIGERIA: POPULATION FIGURES http://www.motherlandnigeria.com/population. Html

Table 2 MIDYEAR POPULATION ESTIMATES AND AVERAGE ANNUAL PERIOD GROWTH RATES: 1950 TO 2050 (POPULATION IN THOUSANDS, RATE IN PERCENT)

EAR	POPULA-TION	YEAR	POPULA-TION	PERIOD	GROWTH RATE
1950	31,797	1996	104,095	1950 - 1960	2.1
1960	39,230	1997	107,286	1960 – 1970	2.3
1970	49,309	1998	110,532	1970 – 1980	2.9
1980	65,699	1999	113,829	1980 – 1990	2.8
1990	86,530	2000	117,171	1990 – 2000	3.0
1991	89,263	2010	150,274	2000 – 2010	2.5
1992	92,057	2020	183,962	2010 – 2020	2.0
1993	94,934	2030	225,866	2020 – 2030	2.1
1994	97,900	2040	279,405	2030 – 2040	2.1
1995	100,959	2050	337,591	2040 - 2050	1.9

Derived from MOTHERLAND NIGERIA: POPULATION FIGURES http://www.motherlandnigeria.com/population. Html

Table 3 MIDYEAR POPULATION, BY AGE AND SEX: 1998 AND 2010 (POPULATION IN THOUSANDS)

	1998			**2010**		
AGE	**MALE**	**FEMALE**	**TOTAL**	**MALE**	**FEMALE**	**TOTAL**
TOTAL	55,920	54,613	110,532	75,657	74,617	150,274
00 - 04	9,942	9,795	19,737	12,447	12,258	24,706
05 – 09	8,162	8,124	16,286	11,073	10,997	22,070
10 – 14	6,768	6,742	13,510	9,865	9,817	19,682
15 – 19	5,881	5,840	11,721	8,510	8,478	16,988
20 – 24	4,788	4,728	9,516	7,014	6,914	13,928
25 – 29	3,982	3,876	7,857	5,817	5,617	11,435
30 – 34	3,355	3,245	6,600	4,612	4,392	9,005
35 – 39	2,798	2,627	5,426	3,591	3,421	7,012
40 – 44	2,339	2,117	4,456	2,900	2,818	5,718
45 – 49	2,085	1,956	4,041	2,392	2,326	4,718
50 – 54	1,787	1,673	3,460	1,989	1,888	3,877
55 – 59	1,381	1,296	2,677	1,692	1,674	3,366
60 – 64	1,024	986	2,010	1,409	1,461	2,870
65 – 69	742	727	1,469	1,022	1,091	2,112
70 – 74	486	487	973	685	753	1,438
75 – 79	263	268	531	400	452	852
80+	136	126	262	240	259	499

Derived from MOTHERLAND NIGERIA: POPULATION FIGURES http://www.motherlandnigeria.com/population. Html

11 SOME INDICESE FOR DEVELOPMENT PLANNING AND COMMON UNITS OF MEASURE.

There are basic knowledge required for any Nation striving for urbanization and development. Data collection and analyses are very important factors that should assist in taking lasting and sustainable decisions. In most measurements, knowledge about influencing factors, the measurement units and their relative interplays are of great consequences.

11.1 Development index

- Population
- No. of doctors and paramedical
- No. of Teachers/Lecturers

- No. of Engineers/Technologist and Technicians
- Quantification of known Natural resources
- No. of specialized Banks
- No. of Primary/Secondary School and the distribution
- No. of employed and unemployed youths
- Volume of food production
- Volume of food storage
- Income per capita
- No. of Primary, Secondary and Tertiary Institutions
- School enrolment at all levels.

11.2 FOOD AND DRINKS: COOKING BASICS CONVERSION TABLE FOR BOTH IMPERIAL AND METRIC MEASUREMENTS AS WELL AS A COMMON EQUIVALENTS CHART

MEASUREMENT EQUIVALENTS

❖	1 tablespoon (tbsp)	=	3 teaspoons (tsp)
❖	1/16 cup (c)	=	1 tablespoon
❖	1/8 cup	=	2 tablespoon
❖	1/6 cup	=	2 tablespoons + 2 teaspoons
❖	¼ cup	=	4 tablespoons
❖	1/3 cup	=	5 tablespoons + 1 teaspoon
❖	3/8 cup	=	6 tablespoons
❖	½ cup	=	8 tablespoons
❖	2/3 cup	=	10 tablespoons + 2 teaspoons
❖	¾ cup	=	12 tablespoons
❖	1 cup	=	48 teaspoons
❖	1 cup	=	16 tablespoons
❖	8 fluid ounces (fl oz	=	1 cup
❖	1 pint (pt)	=	2 cups
❖	1 quart (qt)	=	2 pints
❖	4 cups	=	1 quart
❖	1 gallon (gal)	=	4 quarts
❖	16 ounces (oz)	=	1 pound (ib)
❖	1 milliliter (ml)	=	1 cubic centimeter (cc)
❖	1 inch (in)	=	2.54 centimeters (cm)

11.3 METRIC CONVERSION FACTORS

Fluid Ounces	29.57	grams
Ounces (dry)	28.35	grams
Grams	0.0353	ounces
Grams	0.0022	pounds
Kilograms	2.21	pounds
Pounds	453.6	grams
Pounds	0.4536	kilograms
Quarts	0.94	liters
Quarts (dry)	67.2	cubic inches

12 CONTRIBUTIONS TO MEASUREMENT SCIENCE AND RESEARCHES IN APPLIED PHYSICS.

Vice Chancellor, Sir, the Chairman of this occasion, Ladies and Gentlemen, may I with great humility and respect for Okrika Grammar School, Unique Uniport, and UMIST Manchester echoe my contributions to the road map of scientific world piloted by Isaac Newton (1687) and Charles Darwin (1859).

The menace and havoc created by electrical breakdown process have been well documented in several journals (Owate and Freer, 1986 - 1990).

Fig. 6: Power plant with ceramic insulators

The recent event that occurred in March, 2010 at the transmission cable at Zoo Park, Trans-Amadi, Port Harcourt is a great eye opener to Nigeria. Owate et al (1988', 1989', 1990' and 1992) studied extensively the dielectric breakdown strengths of some cordierite alumina, aluminum nitride and glass ceramic insulators. These materials are normally used as high voltage electrical insulators. Prior to the period, it was published in IEEE, journal of applied physics, USA and journal of materials Science.

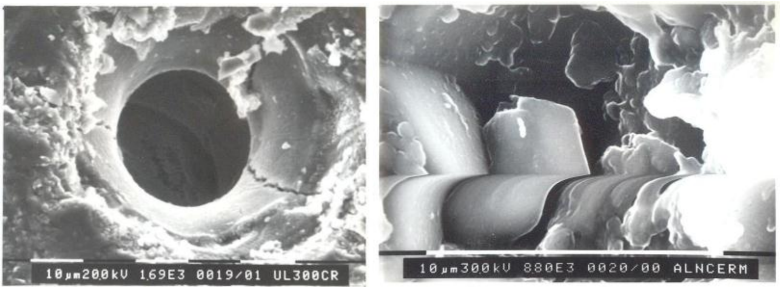

Fig.7: Breakdown crater and surface

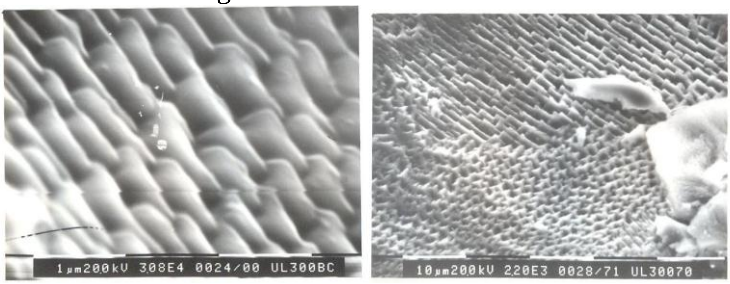

Fig. 8: Dendritic breakdown surface

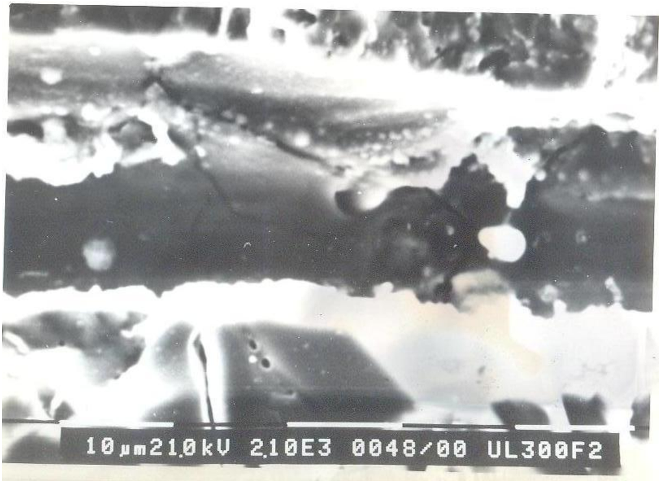

Fig. 9: Breakdown Channel

Sharon Mckeown, (1987 and Gee – 1986) had shown that organic plastics, alkaline halides and some polymeric materials were actively engaged for high and medium voltage insulators. But an American Firm applied some of the materials in the field and they failed below the breakdown voltage (20 kV/mm) after about a year and half. Most of the materials failed between 10 – 15 kV/mm. This was unacceptable and I was contracted to solve the problem because the event was disastrous and lead to loss of clients, money and temporary closure. However, the superior electrically measured properties of ceramic-based materials suggested by Owate in 1988 after extensive research brought back the company into the World market of electrical insulators. This singular achievement suggested to the materials world in 1995 that ceramic-based insulators with well-defined compositions and sintering conditions are more suitable for the more demanding applications in hostile environment. It was also found that alumina and aluminum nitride ceramics of 96% and 98% nominal purities respectively had mean electrical breakdown values of 24 kV/mm and 18 kV/mm respectively. These results were 60% higher than the then pre-casting values and were achieved through compositional design and changes in environmental conditions. It was equally discovered that ceramic insulators breakdown process was associated with an "Explosive sparking" event that produced single puncture channel terminating in a crater at the surface of each insulator. Several types of crystallization structures were identified and classified. For first time it deduced that the A.c. breakdown mechanism of $MgO – Al_2O_3 – SiO_2TiO_2$ and alumina occurred through a combination of electronic, thermal and electro-mechanical processes.

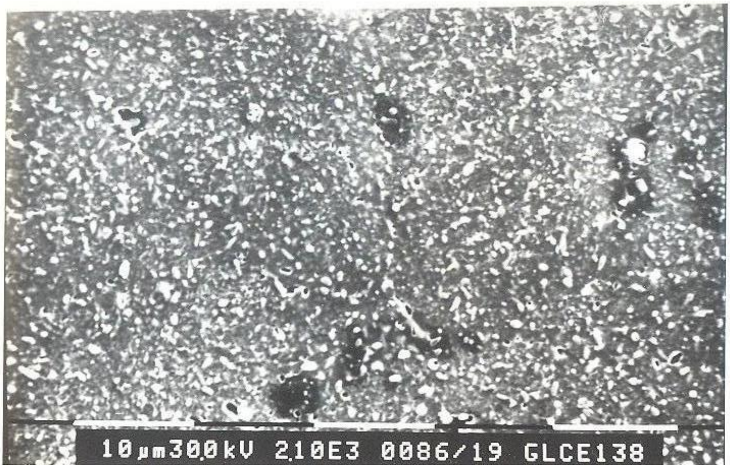

Fig. 10: Un-etched but polished surface of Alumina

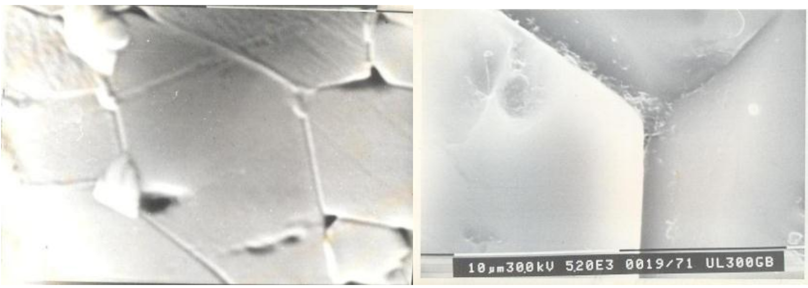

Fig. 11: Thermo-chemically etched surface (Innovation by Owate I.O. 1988)

Consequently in working through these projects, Owate in 1992 established a new etching technique known as **thermo-chemical etching method** for ceramics published in journal of American ceramics vol. 75 (5), 1266 – 68. This method is presently being applied throughout the world. As at the time of writing over 4,169 researchers have successfully used the method whereas 12 mails have been received asking for detail explanation of method. In 1993 Owate, Abumere and Chukwuocha produced a simplified technique for fabricating a P-N junction diode with 75% efficiency (J. Phy. Ed July – Sept). Several research work in electrical treeing mathematical simulation of dielectric breakdown, effects of dopants on ZnO varistor, relative impacts of fossil fuel and solar energy, design of concrete building materials mix-ratio composition, physical and electrical properties of some industrial and edible oils as index for quality control, characteristics of some Nigerian wood and clay products applied the process of measurement system to achieve some degree of high quality results.

Besides Owate's work in the field of environment and corrosion science is outstanding. This earned him membership of the committees that prepared the air and noise pollution standard for RESPA, review of Bonny LNG, EIA, Bonny Export Terminal EIA and IPCO, EPA and Port Harcourt Refinery.

The synthesis and optical characterization of Antimony Copper Sulphide deposited by the Chemical bath deposition (CBD) technique has been investigated. The optical properties studied from the *T* and *R* values show that the film had interesting properties that can be harnessed for diverse technological applications such as fabrication of solar cells; as antireflective coatings; possible application in screening off UV portion of the electromagnetic spectrum; could be effective material as coatings for poultry houses and even as window layers for photocells.

Recently, multi – component thin films of SbCuS have been developed on glass substrates using chemical bath deposition technique (CBD). The films were deposited for 1.5hr (sample A) and 2.0hr (sample B) both at room temperature. The optical properties of the films were characterized using spectrophotometer in the range of UV – VIS – NIR. The minimum transmittance for both samples occurred at 4.18% before increasing exponentially to a maximum of 71.85% within the same wavelength range. The maximum refractive index for the samples occurred at 2.29 at photon energy of 2.21eV before declining exponentially to almost an asymptotic value of 0.11. From the spectra, the band gap were found to be 3.08eV for sample A and 2.72eV for sample B giving band shift of 0.36eV within this proximity studied time interval. The extinction coefficient and optical dielectric constants (and *r I* e e) were also characterized.

The band gap and optical properties indicate that the film has high transmittance and can be of high technological application for fabrication of solar cells, coating of poultry house and as window materials.

13 EVALUATION AND MEASUREMENTS IN DEVELOPMENT.

The importance of evaluation and measurements in planning, design research and implementation cannot be over-stressed. But in Nigeria, Primary and secondary school enrollments are greatly politicized to level that planning for future generations becomes extremely difficult.

Each and every ethnic group tries portending that they are greater in numerical strength since the "national sharing of cake" is a game of numbers. The accuracy, reliability and acceptability of population figures are as good as too good, that many prefer the projected population figures from United Nations. They tell us what our population should be. It is even too sad to say that our current birth and death rates are hardly predictable where accurate records are illusions. It is very obvious from the few examples, that the development of Nigeria in the next century urgently requires a total over-haul of our measurement and record keeping mechanism.

It is equally note-worthy to state that most developmental strides are in-part achieved through funding of researches and application of sustainable and reproducible results. It is on record that Nigerian Scholars are among the most brilliant academics in the world. Nigerians are out there (in Diaspora) assisting Nations, breaking new grounds in many fields (Medicine, Physics, information technology e.t.c) but right here, at home scholarship is hardly appreciated. Our leaders commonly prefer white-coloured technicians/labourers to a well refined scholar with hard-stand on policies and principles. This has only reduced us to outside transfer Technology seekers. This of course will not yield the **CHANGE** that the masses are asking for.

14 CONCLUSION.

The process of adapting a well-defined system of measurement, data collation and storage, research funding geared towards problem solving and infrastructural/instrumentation provisions are “sine qua non” to National development for now and the future. It becomes absolutely imperative that all measurable should be measured and efforts should be made to measure the un-measurable. For in so doing new research grounds are broken and the old ones are refined. This implies that development goals can be set, visions defined and paths to achievement designed, but the ultimate result is achieved through accurate, précised model of measurement system based on scientific data acquisition and results delivery. These principles motivated Owate, I. O in his quest for knowledge and assisted in the contributions that have been stated in this lecture. Thank you all and May God Almighty reward your dreams as you attempt to measure the measurable and the un-measurable.

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WORKS IN PROGRESS

(A) BOOKS

1. Owate, I. O., Introduction to Measurement Science and Instrumentation, (in press).
2. Owate, I. O. et. al., Solid State Physics (in press Physics writers series.).
3. Owate, I. O. et. al; Materials Science and its applications (physics writers)
4. Owate, I. O. et. al; Mathematical Physics (physics writers)

(B) RESEARCHES

1. Design Fabrication and Analyses of Varistor System.
2. Design, Fabrication and Analysis of Materials Coating System for Environmental Control and Protection.
3. Noise and Air Quality Abatement Studies.
4. Corrosion of Aluminum system.
5. Design, construction and analyses of tomato drying system.