UNDERSTANDING CHANGE DYNAMICS IN A STOCHASTIC ENVIRONMENT

By

O. Ibidapo-Obe

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By

O. Ibidapo-Obe
B.Sc. (Hons.)(Lagos); M.Maths, Ph.D.(Waterloo)
Professor of Engineering Analysis and
Dean, Faculty of Engineering
University of Lagos

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PROLOGUE

The Vice-Chancellor, Deputy Vice-Chancellors, My Lords, Honoured Guests, My Colleagues, My Wonderful Students, Eminent Ladies and Distinguished Gentlemen; I want to thank GOD for the privilege being bestowed upon me today to give the 1996 Second University Inaugural Lecture.

I thank my loving wife, Olusola; and my wonderful children, Akinbambo, Omobola, Oyetokunbo and Oyeniyi, for being the perfect partners.

It is appropriate, at this juncture, to pay tributes to my parents who are very much around. My father, Chief Ladipo Ibidapo-Obe, The Risinkin of Ilesa, believed so much in me that he spared no efforts to ensure that I had the best education at my time.

I cannot but acknowledge my colleagues both within and outside the University system for their encouragement, support and the competitiveness spirit that has given me the opportunity to talk to you today. I thank you all.

Now, quite a few of my friends have asked me since the public announcement of this Lecture, what in a nutshell is ***"Change Dynamics in a Stochastic Environment?"***

We know that the only permanent feature of creation is Change and that Change in itself, is effected in time - hence dynamics. It is also clear that we operate in a changing world; a world that changes from place to place, i.e. in space and from time to time, i.e. in time.

An object that changes both in time and space is said to be stochastic. Hence the topic of this Inaugural Lecture.

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1.0 INTRODUCTION

1.1 The Beginning and Quest for Improvement

"In the beginning; GOD created the heavens and the earth" - the planets and the stars, the marvels of the sea, the rugged beauty of mountains, the wonders of the animal world and MAN.

The universe made up of millions of galaxies of incredible size with each galaxy rushing away from all others, faster and faster - the farther they get - the faster they go! What a marvelous creation? What an incredible growth rate? When will it blow up? To emphasize the expanse of the universe; just imagine that it would take 48,000 years to get a feedback to a message beamed only to the outer edge of our own galaxy. All these creations are in a stable state.

In the quest to understand our environment better; two years before Viking landed on Mars, some scientists in 1974; calculated that, as many as 50 million civilizations may exist somewhere in space and that some of these civilizations may have found methods to improve our lives and control the time of death. This is interesting and we want to know more about space, conquer it so that we can improve our lives and control the time of our death! We believe and have faith that we can do it!

Human development is motivated by faith and the zeal to excel. Faith is very fuzzy and fuzziness implies unpredictability. We naturally wish to know how tomorrow will be so that we may influence it our way. Man's initial desire is to "live for ever" - the quest for everlasting life on earth has led to great discoveries in Biology, Chemistry and Physics with Mathematics. The nonfeasibility of this initial desire to "live for ever" resulted in strategic objective refocus viz. "to determine and control the time of death".

Now that we all agree that our sojourn on Earth is temporary - we need to improve our stay.

Engineering makes living worth our while; Engineering searches for ways and means of ensuring that Life is more abundant! The methodology for knitting all these variables together is very intricate - this is the realm of Engineering Analysis and specifically Modelling! The language of nature is mathematics, of change is differential equations and probability. The use of mathematical models to support decision making continues to make great impact on public and private sectors policies; it is the power of modelling that allows us to play GOD.

1.2 The Continuum Concept and Perturbations

The Earth is a continuum consisting of matter. The interactions of the matter generates Energy. This basic principle is a convenient platform for the modelling of human activities. Perturbations appear in time and space - probability theory deals with the study of perturbations in space whilst differential equations look at changes per unit time. All real life systems are stochastic because they exhibit variabilities in time and space.

We shall deal with these concepts in more details later in the discourse - suffice it to say that the earth system remained in absolute stability before human quest for improvement, thus bringing up inherent instabilities within a universe that appears "stable-in-the-large".

1.3 Overview of Lecture

This lecture starts with the physical and human variabilities; man's quest to control and determine the time of death naturally imposes the need to understand these variables in both time and space. We start with statics; perturbations that induces change and the rate of change that leads to dynamics. We would discuss stability, control and of course what we can do in chaotic situations.

The presentation on Science and Technology deals with the need to focus on this sector this sector as a veritable and the only tool for national development.

Science and Technology determines and enhances national prominence or rather national power. National power emanates from natural resources, industrial capacity, socio-political structure and military power. It is becoming evident that the efficient utilization and deployment of natural resources currently depend on an acceptable and egalitarian socio-political structure which, in this country, depends on military power. Military power itself depends very largely on information or rather intelligence .

The only possible way to devolve national power from the military power is if a strong science and technology base can be developed. Even, at that, it is still conceptually difficult because the greatest client of military soft- and hardware is Science and Technology; i.e. the military uses the technology before it gets to the civilian populace.

By and large, however, military power evolves from the citizenry.

Is it not about time that we factor the military into the national socio-political equation before we unwittingly create a ruling class such as the princes of old? For example; if science and technology cannot be enshrined in the short-term; the alternative is that we could all be militarily trained so that we will all respect ourselves, as done in some other countries. This will ensure a stable unchaotic polity and safe environment that can perhaps be self-excited at best!

This brings us to the dilemma of appropriate technology. What technology is to be transferred and from where? How do you fire the Community Technology Engine?

The lecture is not completed until we talk on Computers and the Human Mind - Can Computers Think; have feelings, consciousness, etc? and Where is our country in this scheme of things?

Finally; it was common to say "necessity is the mother of invention"! In our current world, survival instincts breeds invention. Where is Engineering in all these? How can we rapidly aid invention through University-Industry partnership?

2.0 THE CONCEPT OF TIME AND SPACE

2.1 The History of Time and Relation to Space

A lecture on change and dynamics has to be founded on the mystery of the Universe and relationship to time and space.

Time is a physical quantity that ensures change - unlike length and mass: it is difficult to define. Suffice it to say that time measures the sun's movement! The history of time is intricately related to the origin of the universe from the **"Big Bang"** through **"Black Holes"** to the system that generates sunlight (the source of life), gravity and atoms.

One of the most fruitful sources of mathematical intuition is the physical space; it provides a pictorial framework for visualization and conveniently introduces key ideas of continuity and smoothness. Indeed, the notion of real number originates from measurement of spatial separation and of time intervals, both of which are related. Space and Time are combined together to give a 4-dimensional picture of the world and a relationship between time and space derivable as follows (Minkowski (1864-1900)):

1 second = 299,792,958 metres
1 year = 1 light year

and the speed of light taken as 1.

Ordinarily, the speed of light is 299,337.984km/sec and one light year is therefore 9.5 trillion kilometers.

The light cone of origin becomes a spheroid with radius equals to time. This leads to the propagation of light as particles (photons) and straight lines on the cone representing the histories of individual photons of the light flash known as generators. There are variabilities in these straight lines most oftentimes and to get the real situation - the stochasticity must be built in!

2.2 The Black Hole and the Big Bang

As we discussed earlier; when we talk about time - we want to know the origin and better still, the end of time. This leads us naturally to the concept of the black hole and the big bang.

An example of a space-time model with unusual and interesting causal properties is that representing gravitational collapse to a black hole. This development is attributed to Penrose (1965) after an exhaustive search for the beginning of the universe. The Black Hole is defined as a region of the space-time from which nothing, including light, can escape because gravity is so strong. Physical theory predicts that the end-point of the evolution of a massive star, of, say 20 times the mass of our own sun - would be such a black hole. It has a property that signals of particles emitted inside it cannot escape to the outside world but can get from outside into it.

The singularity theory that supports the existence of a "black hole" relates back in time to the **"big bang"** if the general theory of relativity stands correct. The **"big bang"** would be, in theory, a singularity that signals the beginning of time. (Hawkings (1970)). This would have been a convenient platform to define time, based on the causality/inverse problem.

This, however, is currently being controverted by amongst others the inventor himself!; hence, the search for the beginning and end of time continues.

2.3 Randomness In Time And Space - Stochastic Systems

The intricacies explained hitherto and difficulties encountered at obtaining the solution to the quest to determine the origin of the Universe attest to the randomness in time and space in the Universe. The success of Newton's theory of gravitation encouraged Laplace (1800) to argue that the universe was completely deterministic - this might appear fairly obvious at that time because it was adequate for predicting the motions of the planet for up to two and one-half centuries. Also, in the ancient modelling practice, not all the control variables were included in the predictive equations. However Laplace bungled when he included **"human behaviour"** in his deterministic theory. As even at that time human behaviour have been random both in time and space. This anomaly led to the uncertainty principle by Planck (1901); Heisenberg (1926), Schrodinger (1924), Dirac. et. al (1924) and heralded the birth of quantum mechanics.

Quantum mechanics, introduced elements of unpredictability or randomness into science. At first, there were strong opposition to this concept - the most remarkable of which was from Einstein, who contended that **"GOD does not play dice"!**

However, we know that invariabilities and randomness underlies nearly all of modern science and technology. Although I do agree that GOD does not play dice - I wish I know what He plays (if He plays at all!).

Herein, lies our interest in the study of Stochastic Systems; but, I would rather be contented with knowing why and how my machines play dice!

3.0 CHANGE, DYNAMICS, STABILITY, CONTROL AND CHAOS

3.1 Statics, Change and Dynamics

The nature (or physics) of objects is the tendency for every object to move in a straight line towards the centre of the earth. The inherent desire for bodies to move induces "change" and this change or movement is the subject of Dynamics.

Over the past several centuries; several philosophers (Aristotle, Galileo, Descartes, etc.) have undertaken the Whys and Wherefores of Motion:

*	Why does a body move?	To seek its rightful place
*	How does a body move?	Through distance which covered as the average velocity multiplied by time
*	Why do things stop?	By applying an equal and opposite Force!

The "change" that induces motion (dynamics) of otherwise static bodies is exhibited randomly in both space and time.

3.2 Newton's Laws and Relativity

Sir Isaac Newton (1627) in "**Philosophiae Naturalis Principia Mathematica**" proposed and developed models of how bodies move in space and time. In addition; he postulated the law of universal gravitation, by which each body was attracted toward every other body by a force that was stronger the more massive the bodies and the closer they were to each other. Although this remains one of the most influential works in Physics; somehow, by neglecting all other variables - it seems stupid to accept this theory; however, if we didn't, we cannot properly model the relationship. In any case it works sometimes?

Newton subsequently played very crucial roles in the development of his country (the UK) and presided effectively over the industrial revolution as not only the President of the Royal Society but also as the Warden of the Royal Mint, leading a major campaign against counterfeiting! Controversy dogged Newton, even after his death; for example, the One Pound Note issued by the Bank of England that bears his portrait under an apple tree has to be withdrawn in 1984 because the Sun was placed in a wrong place!

Simply put; the 3 Newton's Laws (Axioms) are as follow:

* Everybody continues in its state of rest, or of uniform motion in a straight line, unless it is compelled to change that state by forces impressed upon it.

* The change in motion is proportional to the motive force impressed.

* To every action there is always opposed an equal reaction: or the mutual action of two bodies upon each other are always equal and directed to contrary parts.

With the introduction however, of a 4-dimensional space-time coordinates in 1905 (Einstein and Poincare); the theory of gravity espoused by Newton fails especially for particles that travel faster than the speed of light. Herein comes Einstein's theory of general relativity which is based on the idea that the laws of science should be the same for all observers, no matter how they are moving. It explains the force of gravity in terms of the curvature of a four-dimensional space-time. Einstein contends that gravity is not a force like other forces and that bodies like the earth are not made to move on curved orbits by gravity but follow the nearest to a straight path in a curved space called **geodesic**. Real life forces are random in time and space.

3.3 Stability, Control And Chaos

From the macro-universe with a system of galaxies to the micro-protons and neutrons; all are governed by dynamical

models whose input or impressed forces can be both deterministic and stochastic. The singular objective, is to establish systematic control laws to ensure stability of these bodies and avoid chaos.

There is no absolute definition of stability and the advances in the theory of stability in recent decades have been due to the requirement of control theory. From the time of Aristotle and Archimedes, stability deals with the motion occurring after a perturbation. For our own purpose; if the perturbation does not exceed a defined measure, the unperturbed state is called stable when the change in the norm caused by the perturbation does not exceed its established measure; otherwise the unperturbed state is unstable.

We, therefore, at the design stage establish a control system to ensure stability. The control can exist for the purpose of regulating the flow of energy, information, money or other quantities or some desired fashion; or in other words, a control system is an interconnection of many components or functional units put together in such a way as to produce desired results.

Strange things happen in dynamical systems; some of them such as periodicity and resonance, we know, understand and can control but chaos presents a totally new science of process rather than state. It seeks order in irregularity. New elements of motion viz: fractals and bifurcations, intermittencies and periodicities, folded-towel diffeomorphisms and smooth needle maps present themselves. How does these happen? Strange phenomena indeed and it does occur in the least expected of places.

We submit that the unpredictability of motion leading to chaotic phenomena is largely due to random inputs in space and time.

4.0 SCIENCE AND TECHNOLOGY

4.1 Science, Technology and National Development

Now that our world is essentially stochastic; we require techniques (science) and tools (technology) to cope with the environment.

The subject of technology has been so controversial and overworked within the past decade that perhaps, the least aggressive way to start a discussion on the subject matter, is to first invoke a standard dictionary definition of science and then of technology. In this regard, Chambers 20th Century English Dictionary lists Science as knowledge ascertained by observation with experiment, critically tested, systematised and brought under general principles. Technology, on the other hand, is defined as the practice of any or all of the applied sciences that have practical value and/or industrial use. In other words, whereas science tells us what to do, technology proposes how to get it done in practical terms.

Success at improving both length and quality of life invariably depends on effectiveness of technology in solving the daily problems posed by the environment. To this extent, History of Civilization is by and large the history of technology.

The data and process arising from the practice of Science, which is internationalized, are domesticated in private companies for the purpose of creating products and services leading to the generation of wealth. Technology, therefore, appears to be more national or regional and less international than science.

Science and Technology are the bedrock of national development and indeed the primary basis for the socio-economic advancement of any nation. The new industrial giants of South-East-Asia: Taiwan, Malaysia, Indonesia, Singapore, Thailand and Korea are good examples of the transformational effect of Science and Technology.

In a period of rapid social and economic change, much of which is driven by innovations, leading to a multitude of new products, processes, and services; science and technology are emerging as the basis for [illegible]al comparative advantage.

The spread of science-based innovations throughout national economies has vastly increased the degree of competition in international markets. Other nations have responded to the changing conditions on a revolutionary scale viz. the South East Asian Tigers. Many countries are increasing their already massive investments in science and technology viz. the UK, Germany, Japan and the United States. They have taken pains to renew the human resource base, the scientific and technological infrastructure and the industrial structures of their countries. This has profound implication for us. Our prosperity in the emerging international economy will depend, far more than in the past, on our ability to select, use, create, market, and manage perpetually changing and increasingly complex technologies. Sustaining competition in a knowledge- and skill-intensive international economy requires that we nurture and develop our innovation systems as consistently, as imaginatively and as vigorously as possible. Our survival is at stake!

4.2 Science, Technology and Government

Science and Technology is first and foremost government business. It is the only vehicle whereby government can achieve its objective both in the short- and long-term basis.

Nigeria, should recognise the crucial role of scientific and technological research in the modernisation of nations.

It is therefore reasonable to conclude that a first class human resources base is the critical mass for sustainable development rather than larger-than-sense natural resources base. Greatness must be built upon self-reliance and industrialisation, which can only be achieved through the citizenry.

The human resources base must be developed from the training of Engineers and Scientists in the various institutions with a

solid foundation in basic sciences, comprehensive practice-in-training and close association with the local industries.

After all, technological superiority can be achieved through military power (such as the United States) and/or economic power (such as Japan). The world scenario today projects technology only too clearly as the determinant as to which countries are powerful and developed as well as to which countries are weak and are therefore not developed; since military power depends upon technological know-how!

The solid progress and prosperity of many industrialised countries have been attributed not only to scientific experiments, but also to effective application of information or knowledge. The industrial giants of the world are careful to put in place solid and enduring science and technology information infrastructure. They are ever conscious of the fact that scientific and technological breakthroughs rest on a tripod of laboratory experiments, reflective thinking and information application. The information-conscious nations of South East Asia are known to spend almost two-thirds of their resources on generating, processing and disseminating information.

4.3 Science and Technology Policy Development

In a world that is dynamic and where changes do not always obey natural laws of physics; we need to understand the importance of Energy optimisation as the route to effectual science and technology policy implementation.

Energy, the direct product of science and technology, is directly related to economic prosperity and woven into the fabric of our daily activities. In fact, it is the major factor underlying the strength of any economy, including ours.

Our energy sources (oil, natural gas, tar sands, coal, etc.) have to be carefully exploited for electricity, industrial, agricultural and transport needs with minimum disruption of the ecosystem. Individuals are less likely to take the need to preserve the balance in our ecosystem very seriously.

Governments, given the need to ensure the effective and efficient management of scarce energy resources, are generally constrained to devote more than a passing interest in the development of national capability in science and technology, and hence in the development of a policy framework for the advancement and utilisation of science and technology.

The earliest efforts of our nation at research and development in science and technology dates back with the establishment of Federal Department of Agricultural Research (1939) and the West African Council for Medical Research (1920) and followed rapidly with FIIRO (Federal Institute for Industrial Research Oshodi), PRODA (Projects Development Institute Enugu), etc., etc. We started very well and quite early. However; not only has our development been overtaken by lesser countries - our growth has been stunted.

We therefore need to strengthen the efforts of all the research institutes through a more vibrant Ministry of Science and Technology in order to ensure the effective and results-oriented coordination of the national Science and Technology research and development efforts.

The bane of our development is not in the articulation of policies but in implementation, not so much as a result of funding but more of lack of will and discipline to perform.

For the tax payers to derive any benefit from Science and Technology; it is appropriate at this juncture to suggest that Government should prioritise its Science and Technology goals and focus on innovation that will be of immediate and direct benefit to the greater majority of our people.

It is suggested herein that we need to re-engineer, through absorption, those research institutes and align their functions with those of Universities - thereby creating centres of excellence in the Universities. The Ministry will concentrate on not only policy but also serve as a funding/grant agency for specialised research studies within the Universities.

5.0 THE NATURE OF NATIONAL POWER: RE-ENGINEERING OUR FUTURE

5.1 Factors of National Power

The purpose of enshrining science and technology in the polity is not only to make our lives more abundantly but to be a superior and powerful nation.

Power is the rate of doing work or better still - the rate of transfer of energy. In other words; a nation having ***all*** the resources of this world without tangible applications will come to nought. National power, which is derivable from Energy, comes from the transfer or application of the knowledge of science and its use (technology).

Much of East Asia's dramatic growth is due to superior accumulation and allocation of physical and human capital to highly productive investments. This is constantly supported with combinations of policies including market-oriented "fundamentals" and tailored government interventions.

We posit, that in the large, the miracles of East Asia come from the rapid applications of Science and Technology to ensure more rapid output and productivity growth in agriculture and industry, higher rates of growth of manufactured exports and higher initial levels and growth rates of human capital. We can do as well if not much better!

In general, the classic elements of national power are Natural resources, Industrial capacity, Social-political structure and Military strength. In other words, the factors of national power depends on parameters such as Geographic (including location, configuration, topography, and size); Demographic (including rate of growth, age, and productivity); Economic (including mineral, agricultural, energy, water resources and the production policies for employing these resources); Organisational (including social, governmental structure, management skills and methods); Psychosocial (relating to attitudes, values and motivation) and Military (with consideration to national policy, military policies, forces in

being, research and development, as well as education and training). We rank superior to several other countries on these scales except perhaps on Psychosocial and Organisational ratings.

Natural resources is assumed to include "geographic situation" and military strength, or power, comprises only one of several elements or factors. Yet, in terms of absolute national power, the others are significant in an ultimate test only to the extent that they contribute to potential military power and more precisely, to the extent that they can be converted or mobilized to become actual military power. It is the people who convert and use natural resources to achieve national power that makes the country great!

5.2 The Military Power And Scientific Knowledge

Military power is the capability to employ armed forces effectively in support of national objectives by exerting influence on the performance of other nations to its own advantage. Military power has 12 characteristics including: Size of the armed forces; Composition of the armed forces (in terms of balance or allocation of resources to the military services and within services); Quantity and performance of equipment or hardware; Logistical reach or range; Availability of forces for effective employment, Capability of performing sustained, active operations; Mobilisable resources and productive capacity; National willingness to employ force; Leadership and doctrine; Communications and control; Military intelligence effectiveness; Manpower quality in terms of skill, training, physical stamina, morale. All are dependent on effective application of science and technology skills.

There are at least four different aspects of military power; these include its exercise-in war as by threat, availability, effectiveness and usability. Effectiveness is essentially a reflection of quality whilst "usable" military power is quite a different thing from "actual" or "available" military power. Power, can in fact be actual, it can be available, and yet still not conceivably, or credibly, or rationally usable in relation to certain national objectives. In other words; we can acquire

sophisticated weapons but remain powerless if they cannot be effectively mobilized.

The major developments in Science and Technology, such as tele-communications, aerospace engineering, transportation, etc. emanates directly from the military research and development efforts. The military has always served as the testing ground of civil technologies.

The Nigerian Military Strategy derives primarily from the National Interests and Objectives; the core of which incorporates the maintenance of Nigeria's territorial integrity, sovereignty and economic independence. These national interests can only be preserved through effective national security; the responsibility of which is primarily military.

Our military strategy must therefore incorporate national security objectives such as self-preservation or survival of the entity known as Nigeria without serious external threats to those values and interests on which the country puts so much premium; prosperity and economic well-being; good international image or prestige; protection of the nation's strategic resources as well as its investments at home and abroad; protection and promotion of national ideology; peace, implying the absence of the use of armed forces in conflict over interests or a state of affairs from which armed conflict is absent; power, which, in international politics may be defined as the ability to affect the actions, thoughts and feelings of others; and bringing about favourable political and economic situations in contiguous countries which can best serve our national interests. Appropriate national strategy is therefore determined by internal, external and economic threats to the national interests.

5.3 Optimum Strategic Options - Re-Engineering

It is appropriate, to have a strategy that can optimize the utilization of abundance of our human and natural resources to maximize our national power. This is a classical control policy. The strategy herein is the objective function to be maximized. The military is part-and-parcel of our national resource and we

have to use it optimally to achieve national prominence. We can now re-engineer our national objective function, factoring key sectors of the economy into the natural equation whose degree of correctness will depend on sensitivities of input variables.

We have been able to prove succinctly that the key to national eminence is Science and Technology. The country had made several starts and stops over the past decades in this sector; each review seems to take us further from the objective of national prominence. It is about time that we undertake a fundamental rethinking and radical redesign of our processes and procedures to achieve dramatic improvements in critical, contemporary measures of performance. We need to pause and deliberate on Why do we do what we do and why do we do it the way we do?

For example; if Nigeria, is to be recreated today with all our known SWOT (Strengths, Weaknesses, Opportunities and Threats) and given the current technology - what will it look like? Are we going to tackle national problems the same way we had and are? In order to answer these questions with minimum bias; we need to abandon our former concepts and of course, the procedures or processes including prejudices. We must understand that we are all fellow travellers bound to the same destiny as a nation. The key notion inherent in this strategy is - the parts must work in harmony with the whole; otherwise it may be catastrophic!

6.0 APPROPRIATE TECHNOLOGY AND SUSTAINABLE DEVELOPMENT

6.1 Appropriate Technology and Development

National Eminence can only be achieved through Science and Technology. Science is international; technology can be national or local and is only useful if it is appropriate and could be a tool for sustaining our development. The key word here is appropriateness or utility. The technology that we must imbibe must be appropriate.

Appropriate Technology can be taken as the technology suitable and necessary to enable the individual human being to live a life of maximum quality, earning by their own work a fully adequate standard of living and satisfying their creative needs, in perpetual stable equilibrium with the environment.

This definition implies that such technology will be equally appropriate for the people of developed and "developing" countries; however the approach differs from opposite sides because the developed countries are using far more of the resources of the world than can be maintained while the rest of the world is unable to achieve an adequate living.

Appropriate technology aims to make workers more productive so that they can achieve a better standard of living, and is not, necessarily, a technology that has to be transferred from the developed country to the developing country. It is also not an intermediate technology. It is a technology which should be based on need and is community inspired. It makes use of the best of modern knowledge and experience.

Appropriate technology generally has characteristics of low capital costs, use of local materials, employment creation and community based, manageable scale and understandable technology as well as market availability.

The underlying principles of sustainability and responsibility ensure that mankind must sustain a stable equilibrium with the Earth and that the technology can only take root and grow

steadily if the people who benefit by it are responsible for re-generation. Energy must be conserved.

6.2 Transfer of Technology and the Community Technology Engine

Appropriate Technology is that that can be transferred. Technology Transfer is sometimes referred to as copy technology; it is a system where a state-of-the-art technology (tools, equipment and sometimes ideas) are imported (under one type of arrangement or the other), disbowelled, duplicated, digested and mass-produced.

The transfer of technology is not simply a transfer of techniques or a mechanical change of procedures and tools but, on the contrary, an adaptation to the rhythm of needs to the varied forms of development and to the socio-cultural environment. From this point of view, the transfer of technology must assume not only the possibility of its integration to the economic, social and cultural milieu but also the capacity, by the scientists and engineers to know how to manage it, to penetrate the principles and the mechanisms of it to the point of being able to recreate the technology.

The technology transfer concept seems to have worked wonderfully well for Japan, after the Second World War as well as in recent times for the tigers of South-East Asia (Korea, Malaysia, Taiwan, Thailand, Indonesia and Singapore). The concept of appropriateness of technology transfer, has been hitherto extensively discussed by Engineers and Development Economists, as a tool for rapid acceleration of development in our economy.

But can we really transfer technology within our socio-political framework? The Federal Government, in an effort to "filter" in some technological innovations, from the "packaged deals", set up the National Office for Technology Acquisition and Promotion (NOTAP).

The primary function of the NOTAP is to register imported technology with a payable arrangement fees from the

"transferor" in order to encourage the "transferee" to dissipate the knowledge.

Clearly, the NOTAP concept is useful but the implementation and the impact of the scheme on the economy so far, is another matter. Somehow; we have not seen much in terms of industrial output and yet we cannot subscribe to the call of a vocal minority to "steal" the technology (on the assumption that it cannot be willingly transferred); it is quite evident that the transferee will not knowingly part with their knowledge and expertise unless there is a perpetual agreement/arrangement that guarantees his market. This knowledge is their "survival" link to the developing countries.

In this stead, and with the preponderance of Nigerians all over the world occupying strategic positions in research, development and marketing organisations; we can change the untoward effects of brain drain on our economy easily into an opportunity by using these experts as human capital exports. Knowledge is universal, resources are in a continuum - what is lacking is the infrastructure or rather the enabling environment to facilitate rapid emancipation of our people into the fore-front of development. Non-resident Nigerian Experts are more likely to import and transfer knowledge/technology to their kit-and-kin in a more effective and efficient manner.

In fact, whether a country produces technology or uses it strategically, is dependent on an environment which must be rich in specialized infrastructure, specialized technical, financial, education, management and marketing services and highly skilled workers. This environment has to be created in order to be part of the change process; every community must develop its own "**technology engine**" to meet up with this rapid/evolutionary development.

A community technology engine will be a process whereby communities will put up and support technology based infrastructures such as high quality educational institutions with good links to the region's economic and cultural sectors, local pools of venture capital, enlightened local public and private leadership that is able to engage in flexible, collaborative

planning, a pleasant environment with cultural amenities, a good physical and telecommunications network, a well-educated, highly skilled and motivated work force and a complex of innovation-producing and innovation-using institutions such as advanced manufacturing firms and public research institutions with good links with the local productive sector. What dynamics will change our communities to support a virile technology engine and who are the players?

The players in the community technology engine include the high-technology sector; every local industry and business, including general business associates; educational research and scientific institutions; planners and officials from all levels of government, persons involved in technology transfer, such as brokers, institutional representatives and consulting engineers; financiers, bankers and local investors; labour groups as well as elected representatives.

These people are responsible for providing the leadership and guidance that communities need to fire up the technology engine.

We have preponderance of these players in Nigeria. We need to use and motivate them.

6.3 Model Development and Procedure for Solution Scheme

Technology in all its facets and modes is intertwined with development through manpower (or more precisely education), food self-sufficiency (or agriculture), raw materials, trade (international trade and finance), market, health, culture and welfare.

We can infact develop a functional relationship incorporating these variables. This model can be solved using stochastic, dynamical and fuzzy theory introduced in 1965 (Zadeh) as a methodology to manage uncertainty. The objective is to develop a community technology engine!

The basic idea, therefore, is to introduce some formalities in the restructuring of vagueness in these highly dynamic decision

problems in a stochastic environment. The formalisation/ systems approach which, will naturally lead to several applications and may lead to the development of Expert Systems to solve the ensuing problems.

Some of the considerations in this development will include knowledge, capital, materials, hardware, software and labour (as inputs) through the system (engineering, production, personnel, manufacturing, management, facilities) to better products, better services, more profit through applications (as outputs).

7.0 THE NEW APPROACH-INFORMATION TECHNOLOGY

7.1 Scope of Information Technology/Informatics

To understand and cope with change in a stochastic environment - you need the power of information technology to save and crunch large data and make decisions. Ordinarily, decisions are based on experience (data) and logic.

Modern technological development is predicated upon the new vistas in information revolution - the key parameters that determine the reliability of procedures and processes in decision-making. Computers are the tools that facilitate this revolution thereby ensuring optimal utilization of "the human brain".

The frontiers of knowledge are being rapidly expanded as a result of new developments in Computers and Information Technology.

Computers have become a "sine qua non" to national technological development. The rates at which new technologies are launched within the computer industry is indeed phenomenal; every quarter, a new product which is introduced gets matured in 18 months. This rapid innovativeness is a challenge to our national psyche. It is more so, when we know that our own kith-and-kin are at the forefront of the development in a more friendly and encouraging environment provided by other nations; some of which are less endowed but clearly more disciplined and organised than ours.

In recent times, the computer culture has grown from a luxury to a utilitarian resource that have become almost an index of viability for national economies, and therefore an index of power in world politics. The more accessible computer technology is to the economy the more so also are other world's pool of resources and the more competitive therefore is the economy.

We need therefore to embrace this ever-evolving tool and utilize it to achieve our development objective. Information Technology, has become the engine of our modern society, fortunately, it is independent of regional boundaries, race, sex, religion, etc.

In the software area; computer programs now deal with adaptive problem solving through interaction with a professional or other specialists; thus leading to the recent upsurge of interest in artificial intelligence and knowledge-based (expert) systems. Expert system has some problem-solving capability tied to an organised base of knowledge.

The dynamics of change in Information Technology is only limited to human imagination and therefore, highly stochastic. It is wise for all to be computer-friendly.

In order to get the Faculty of Engineering in this University properly positioned in the scheme of things that are and are to come; the undergraduate curricula have been extensively reviewed with an increased exposure to Fundamentals of Computer Operations, Operating Systems, File Maintenance, CAD (Computer Assisted Design), Analysis of Visual Information, Basic Design and Operations of a Program (PASCAL), Data Types and Structures, Advanced Programming Techniques (C++), Numerical Methods and Software Development Methods.

7.2 Machine and Human Knowledge

We now come to discuss a topical issue on the relationship between Man and Machine; the inventiveness of Man led to the development of Machines. Machines are dynamic and designed to operate in a stochastic environment.

It was only in 1959 when it was thought that computers could correct mistakes and memorize the incident for future reference - a form of learning: which can be built into the next generation of computers - a form of inherited experience thereby enabling computers to design computers and control the machines that manufactured computers - a form of breeding; machines which

could not only translate existing languages but even create their own - a language not of literacy but of numeracy; machines that could compose music; could recognize and memorize patterns and pass them on to their machine progeny. Computers from their accumulated experience, could memorize laws and invent machines that human beings had not even contemplated.

Computer programmers are learning from Biology and adopt the Darwinian survival of the fittest theory in terms of so-called genetic applications (GA) software. No wonder; Computers generate and spread viruses! Such software incorporates genetic algorithms that mimic evolution: Lines of computer code perform like living organisms, which means that they constantly interact with one another and are mutating. So the software evolves, rearranging itself to achieve the best solution to a complex problem. GA software are being used to manage financial portfolios, design communication networks and improve manufacturing schedules.

Now, up to the minute information, could be beamed to computers in our cars to steer us clear of traffic jams, blind people could find their way around by listening to a talking computer and business people could work on the move with a portable office-on-their arm. This year, speech scientists have made a remarkable breakthrough by developing a computer which has given a voice to a 13-year-old girl. The potential benefits to thousands of people like her are enormous. There are several other innumerable applications!

And in the not too distant future, we could be zapped into a "virtual world", talking to people in the same computer-generated room without having to travel thousands of miles away to come face-to-face with them. The new technology allows people to work around inside virtual worlds created by computers which can be transmitted down telephone lines.

In the future it would mean, for example, that architects and their customers could walk around inside buildings not yet built and chemists may be able to explore molecular models from the inside.

The above inventions are quite astounding; however, the major question remains:

"Can we develop a model for machine-emotion" or more succinctly - Can Machines Think?

I believe that machines can think as programmed. They have no consciousness neither can they evoke emotions! They are at best "His Master's Voices".

Computers do not and cannot reason as brains do, because they lack imagination. Computers "reason" when they manipulate precise facts that have been reduced to strings of zeros and ones and statements that are either true or false whereas the human brain can reason with vague assertions or claims that involve uncertainties or value judgements. We have not given up yet; we are working on the acceptance of "almost true" statements in theory of computation.

Unlike computers, humans have common sense that enables them to reason in a world where things are only partially true or rather fuzzy.

Herein comes the development in Fuzzy theory or logic. Fuzzy logic is a branch of machine intelligence that helps computers paint gray, commonsense pictures of an uncertain world. Logicians in the 1920s first broached its key concept that everything is a matter of degree.

Fuzzy logic manipulates such vague concepts as "warm" or "still dirty" and so helps engineers to build air conditioners, washing machines and other devices that judge how fast they should operate or shift from one setting to another even when the criteria for making those changes are hard to define.

It is clear therefore that the future is stochastic in terms of what will happen and when will it happen!

7.3 Nigeria and the Information Technology

Information Highway, Information Super Highway and

Multimedia are variously referred to as the output of the information revolution occasioned by the advances in computers and communications. It can be summed up as the consequence of telecommunications, computing and entertainment.

When it first appeared in the forefront of the economic stage, two questions were posed in connection with multimedia, the first of which had to do with its degree of quality and the speed with which it would develop. Both questions have since been largely answered by changes in consumer behaviour which have seen the demand for more and more computer and telecommunications exposure, coming with the explosions of personal computers in the office and at home and through the increasing availability of interactive services.

Indications are that in the foreseeable future, communication will be characterized by man and machine, exchanging information over any or a combination of data, image voice or multimedia, as the medium, and in a simple reliable and efficient manner.

Unfortunately, Nigeria appears to be in the fringes of this information highway, apparently by choice, apathy and lack of direction. There are quite a few reputable service providers in the country but with a poor telecommunications infrastructures; there appears to be very little that can be done! Our recent efforts to restore telecommunications services to areas where it has been disrupted for one reason or the other is in my opinion, a testimony to our apathy. We would rather import the technology rather than adapt it! In other words; we are static in a dynamic world.

Our country exists in a technological age where the mode of information dissemination is critical. If the country is to make any progress (or in fact stay "developing") there is an urgent need to understand and take advantage of the information revolution. Every country has the technology it deserves and it is now an uncontrovertible fact that only nations with advanced telecommunications infrastructure can attract foreign investments; no one puts his money where he cannot reach.

We need therefore to develop and sustain a vibrant telecommunications industry, based to a large extent, on home-grown technology. Investments in rural communications is indeed a must, if significant economic growth is to be achieved in the not-too-distant future.

This is our route to understanding the change dynamics in an essentially stochastic environment.

8.0 CONCLUSIONS

8.1 Survival, Invention and Engineering

At creation, of all living creatures, man was least likely to survive. Man has continued to dynamically change his environment; without fur or feather, or scale, he stood naked to the elements; without fang or claw to fight his predators, without the speed to elude them, or the ability to take to the trees like his cousins the apes, he was physically at a hopeless disadvantage.

What man evolved to deal with his deficiencies was a capacity to invent (this is engineering). He had not only the ability to perceive; he had imagination (this is science). He did not just improvise to meet a contingency as the ape did; he planned ahead (this is management)!

At some point, he realized that he could defeat his enemies by outreaching them. It is clever of a baboon to pick up a stone and fling it at an enemy, but it is a big step forward to put that stone on a stick and use it as a club - a step no baboon is capable of taking since it is wholly conceptual. The club is the extension of the forearm and the fist. The packed punch that man used against his own kind could serve against more dangerous animals, if the fist were a stone and the arm were extended by a shaft. The sharp-edged flint that he used to cut open the skins of animals became, for offensive purposes, a "fist-fang," a crude dagger. Inserted in the end of a stick it became a spear to be thrust or thrown. The sling became a flexible, more powerful form of the cupped hand. And all of these were a long way, conceptually and in time, from the bow, the first device in which energy could be stored and released at will. All these were the first tools that man's inventiveness had produced to help him survive in a stochastic, dynamic and unfortunately perilous world.

He invented machines. The terms "mechanization" and "machine" actually derive from the Greek *mechanaomai*, i.e. "contrive a deception" - a meaning we still recognize in the word "machinations." Today, the word is commonly

understood to mean an apparatus that has at least some moving parts and combines several principles into one unit that will produce work.

Be it car or plane, telephone or computer, the specific power of modern technology lies in its ability to remove limitations imposed on us by our bodies, space and time. It eliminates exhaustion, distance, duration and social dependence.

8.2 University - Industry Partnership

What framework do we have to optimize our coping strategies in a stochastic environment?

The prevailing technology defines the limit of any society's ability to command the resources at its disposal to the service of human needs. The needs include provision of food, transportation, communication, housing, health care, education, administration and tools in the processing industries. In order to make progress in science and technology, there must be a close link between the University and the industry. The University is to engage in invention and innovation in goods and processes while the industries are to sponsor research and market the results. Such interaction promotes growth and self-reliance.

Presently, in this country, both the Universities and the industries are beset by problems of deterioration of the economic environment, which impede their efforts to perform their traditional respective roles. Because of it, virtually all universities are in various states of decay. Their rehabilitation, in my view, now ranks among the most urgent services required in this nation.

It is the Universities that will provide the manpower to manage all our other services; therefore, by neglecting these Universities, we are indeed implanting those other institutions with a malignant tumor that will lead to our ultimate annihilation.

In present circumstances, the local environment is hardly capable of rehabilitating higher education. The necessary resources are simply not there. Even, when Government rehabilitates through an economic windfall a.k.a. PTF (Petroleum Trust (Special) Fund); the rehabilitated infrastructure will need to be supported.

How can we avoid annihilation in our present environment if we are not to continue in the illusion of our vanishing resource base?. Universities have to provide services in the that will attract industries through the adaptation of University engineering education to industrial needs, the funding of joint University-industry exhibition, symposia and seminars, the identification of effective ways and means of improving the transfer of research results to industry and the creation of new and improved products and services as well as jobs for Nigerian youths.

The University must develop through a government supported "Centre of Excellence" scheme; spin-off companies from the research activities in the various faculties, especially the Faculty of Engineering of the University of Lagos. This was the primal objective of the founders in 1983 of UNILAG CONSULT - the University of Lagos Consultancy Services.

It is therefore suggested that in the re-engineering efforts suggested earlier on in this discourse that whilst the Universities will have to re-engineer/rationalise their vision; Government should enable a federal granting agency for the purpose of encouraging cooperative research and development, industrial research chairs and technology diffusion in such a way that industry will participate equitably not only in the funding but also in the implementation of the research and development projects.

8.3 Engineers-In-Society

We have been able to conclude that every nation, to continue to exist, must be technology driven! and that for Technology to develop, there must be an enabling environment! This enabling environment depends on certain historical, cultural and

sociological foundations; a political system that ensures stability of policies and viable infrastructural facilities (including education).

But in our part of the world, especially, things often don't work "according to plan". Unused equipment, rusting machinery and factories working at sometimes 15% of their capacity are eloquent testimony to this dilemma in our world.

Most invariably; the right environment do not exist in our country, which by and large has been and unfortunately continue to be characterised by dependency syndrome, massive importation of finished goods and complete exportation of raw materials. This is a challenge to Engineering. Infact; it is only Engineers that can sustain any worthwhile development. Engineers must and should provide the much needed value-added to our standard of living.

Finally, where Engineering in all these, we may ask? It lies in the fragile magic of technology in development between what we are now and what we should be. Engineering is an all encompassing system. It is not enough to innovate; the ultimate is to have a technological edge in the market place.

It is Engineering that will provide the basis for the serious development of the Community Technology Engine. The products of the modern world only functions as long as large parts of society behave according to plan. Coordination and scheduling, training and discipline, not just energy, are the elixir of life for these exceedingly compliant devices. It is the Engineers that can put them together to work as a reliable system.

We need therefore to optimize the products of science and technology for improved agriculture production, effective raw materials utilization, acceptable income level, vibrant exports drive and reliable infrastructural development through the new developments in Engineering emanating from current studies in Artificial Intelligence, Expert Systems; Stochastic Theory, Neural Networks, Evolutional/Genetic Programming, etc., etc. for the general good of the majority.

Let us get our community technology engine up and running so that we may understand change dynamics in a stochastic environment!

EPILOGUE

Vice-Chancellor, Deputy Vice-Chancellor, My Lords, Honoured Guests, My Colleagues, My wonderful students, Eminent Ladies and Distinguished Gentlemen; I have taken liberty of an inaugural lecture to discuss some of my inner thoughts on ***Man, Creation and Inventiveness.***

I have examined the role of Science and Technology in the emancipation of Man and indeed as a veritable tool to free Man from environmental yoke.

My interest in this topic has been on for several years and become partially crystalised from 1972 and is evidenced in several of my publications beginning from 1975 (J. of Instrument Society of America, Vol. 6, No. 1, pp. 181-184) through 1981 (Solid Mechanics Archives, Vol. 6, Issue 2, pp. 169-191) to 1995 (Applied Mathematics and Computations, Vol. 69, pp. 159-185).

With the new horizons in information technology and the power of computing; my research into the question ***"Can Machines Think?"*** *is being intensified.*

For individuals, communities and the nation; the need to understand change dynamics in a stochastic environment is a necessary and sufficient condition for growth.

I thank you all for your patience and attention.

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