Design Parameters and Conceptual Analysis on Gas Resource and Infrastructure Management: Trans-Nigeria Gas Pipeline Projects in Nigeria

Neeka Jacob[1], Peter Egheneji[2], Nwosu Bernard[3]

[1,2]Research and Documentation Division, Petroleum Technology Development Fund (PTDF), Memorial Drive, Central Business District Abuja, Nigeria.

[3]National Petroleum Investment Management, Nigerian National Petroleum Coorporation, NNPC, Nigeria.

***Abstract*—** *Gas pipeline network and indeed gas infrastructures in the industry are liken to arteries and veins of the body. Blood circulation in the body systems travels through arteries and veins while gas resource travel through network of pipes for industrial and domestic purposes. Nigerian dependency on oil in the last 50years, has been characterised with reserves depletion and infrastructural decays. Therefore, the urgent intervention for Gas Domestication Project cannot be over emphasised. There are endless investment opportunities that abound in the natural gas sector of the Nigerian petroleum industry. At present, the annual gas production in Nigeria is about 2000 BSFC which is remarkable for an oil dominated economy (Figures 1, 2 and 3). Therefore, the initiatives for sustainable gas domestication projects such as the Calabar - Umuahia – Ajaokuta (CUA) and the Ajaokuta – Abuja – Kano (AAK) are laudable in terms of boosting economic resources for future investments. The rapid quests for industrial development of the country necessitate the conceptualization of the Trans Nigerian Gas Pipeline Projects. The project was divided into two segments the Calabar – Umuahia – Ajaokuta (CUA) trunk and the Ajaokuta - Abuja - Kaduna –Kano (AAK) trunk line respectively. The CUA is a 681km, 56" underground single-phase pipeline while the AAK is a 585km, 56" underground single-phase pipeline respectively. The spur lines were design to withstand maximum of 24"and minimum of 22"respectively. The entire project cycle from conceptualization, design and completion were undertaken within two years with about eighty-five (85%) per cent Nigerian Content. The Nigerian engineers and scientists in collaboration with the consultants, deliver the project on schedule (Table 1). The implementation strategy was predicated on the utilization of Critical Path Method (CPM) and Site Man-hour and Cost Control (SMAC) approach for project scheduling, monitoring and evaluation as well as cost control activities all through the duration,(Equations 1-6). Risk determination and safety checks were carried out at each stage for Environmental Impact Assessment (EIA), Front End Engineering Design (FEED), Detailed Engineering Design (DEED), Hazop and Hazid Safety processes, Helicopter Overfly and Right of way Mapping, Cost and Constructability Review and Invitation To Bid (ITB) documentation etc were scheduled and completed. Timely completion of the engineering design and documentation of the project was fundamental to the procurement and construction of the pipeline network. Procurement and construction work schedule are expected to increase industrial development of the country. Efficient gas utilization through gas to power projects, industrial parks along the gas pipeline routes is also affected. This study is expedient in the actual analysis and review of the initial engineering design and safety codes with a view to ensuring compliance with industry standards. The study is also significant as reference material for the actualization of the vision of designing and constructing a world class Trans-Nigerian gas pipeline projects. It will also serve asa reference material for administrators and decision makers on effective deployment and management of resources on gas pipeline projects in Nigeria.*

Keywords*— *Conceptual Analysis, Critical Path Method, Site Man Hour and Cost Control, Infrastructure Management, Right-of-Way, Design Parameters, Environmental Impact Analysis.

I. INTRODUCTION

There is a global shift from solid and liquid fossil fuels (coal and crude oil) to cleaner and more sustainable gas and renewable energies. This is due to the global concerns about the effects of energy production and consumption on the environment (Lyons and Plisga, 2005). The Trans – Nigeria Gas pipeline projects were conceptualized to accelerate domestic gas utilization and maximization of the resources for the development of the industrial sector and enhanced economic growth. These projects were broken down into two segments "the Calabar – Umuahia – Ajaokuta" (CUA) and the "Ajaokuta – Abuja – Kaduna – Kano" (AAK) pipeline projects respectively. Fundamental to the industrial revolution of the country is gas resources which the country's proven reserve is estimated at about 198TSCF. Gas pipeline projects across the globe have been a source of massive income for the country of origin as well as those desiring to tie-in from the producer pipeline routes. The conceptual framework on the Nigeria gas projects and its expected benefits to the transformation of several industrial parks and business pevolution across the country makes it one of the many instruments for sustainable development. Thus, the standard applied methods of project evaluation from conception to commissioning finds its usefulness in this paper using the Critical Path Method (CPM) and Site Man Hour and Cost Control (SMAC). Critical path method (CPM) determines the best period to schedule each event in a project while site man hour and cost control (SMAC) applied to project management aimed at ensuring effective utilization of time and resources for efficient production at minimal cost (Abam 1997).This approach has been adopted in several test cases to address the question of how soon the project will be completed, when is each phase of the schedule meant to start and or finish, what are the critical phases of the project that should be finished on time, what are the cost implication and, how efficient is the performance at the end of the stated period. The Trans-Nigeria Gas Pipeline Projects were designed to have a minimum of twelve gas compressor stations from the beginning in Calabar to the end in Kano.

The gas compressors needed for the projects comes in different designs and always complex to assemble for effective maintenance. The industry is also dynamic and demands competition and efficiency using sophisticated technology. However, the guiding principle is to optimize the system always. This integrated approach makes the Trans-Nigerian Gas Pipeline System design complex as one unit affects several others. The modification of the several gas compressors stations along the gas pipeline routes and or redesign of compressors to function using the pulley-chain transmission system is not a mean task. The risk level, operational and managerial expertise needed for the smooth and standard design are equally high (Chi. Ikoku, 2004). The possible workability of the project without damage to other equipment requires that key activities (operations) be identified and done, and sequence of all such activities or event phases, should be arranged in a network at a specified time interval. Besides, the question that arises on the possibility of the compressor to perform efficiently and effectively for a long time was determined. The actual cost advantage and technological gains of on-time design pump stations could be address through CPM and SMAC analysis technique. Nevertheless, the decision needs to be taken, maintenance must be carried out on the compressor and production operation must continue in the oil industries at an optimal rate and in a safe environment.

This is the focal point on which SMAC found its relevance in the project optimization of compressed gas in the oil industries. The evaluation of assigned time at the end of stated period, the determination of the efficiency of the project, the overall performance and the cost benefits are pointers to the effectiveness of this approach in the project management and optimization processes applicable on the Trans-Nigeria Gas Pipeline Projects.

II. REVIEW OF GAS INFRASTRUCTURE IN NIGERIA.

Nigeria is described more as gas endowed nation with over 198 trillion cubic feet of proven gas reserves. The potential therefore to harness our gas resources to increase export earnings and boost our domestic industrial base, through power generation and downstream petrochemicals, remain enormous. To this end the Nigerian government has initiated numerous gas infrastructure projects to ensure domestic gas supplies for industrial development. These projects, at various stages of initiation and completion, include the following: (NGMP,2012): -

- Escravos-Lagos-Pipeline-System (ELPS) Phase II
  - 36-inchx342km, 1.1 Billion standard cubic feet/day capacity
  - Targeted for completion in 2019
- Obaifu/Obrikom – Oben (OB^3) Pipeline
  - 48 inches /36-inch x 127km, 2 Billion standard cubic feet/day capacity
  - Targeted for completion in 2019
- Odidi-Warri Gas Pipeline Expansion (OWEP)
  - 40-inch diameter x30Km
  - To transport 440 million standard cubic feet/day into the ELPS
  - Aimed for completion by 2019
- Ajaokuta-Abuja-Kano (AKK) Gas Pipeline
  - Part of Trans-Nigeria Gas Pipeline
  - First EPC Contractor Financing model
  - 40-inch diameter x 614km, 1.8 Bscfd capacity
  - Targeted for completion in 2020
- Qua Iboe Terminal– Obiafu/Obrikom Gas Pipeline
  - 36-inch diameter x261km pipeline

- To transport 400MMscfd from Qua IboeTerminal
- Targeted for completion in 2020

These projects are targeted for completion, all things been equal in 2023, to increase Nigeria gas export capacity and revenue generation and domestic gas utilization in the gas value chain for industrialization.

TABLE 1
ACTIVITY BASED DESIGN PARAMETERS IN PROGRESS

	BIDDERS INFORMATION Issued by MPR on 12-Sep-09		**CONCEPTUAL DESIGN STUDY Calculated by Consultant 02-Dec-09**		**CONCEPTUAL DESIGN STUDY MPR's Specification Issued on 05-Feb-10**	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Major and Minor Components, mole%						
Methane	80.45	81.64	75	-	80.45	87.68
Ethane	5.91	6.08	-	10	6.08	6.46
Propane	3.67	3.77	-	5	0.61	3.67
Butanes	2.42	3.04	-	2	0.13	3.04
Pentanes and heavier	1.6	1.83	-	0.5	0.07	1.83
Nitrogen and other inerts	0.69	0.73	-	4	0.73	0.73
Carbon Dioxide	3.97	4.2	-	4	4.2	4.32
Other Characteristics						
Pressure psig	1,000		1,000	1,250	1,000	1,250
Gas heating value, KJ / Nm^3	37.750	42.840	35.400	42.800	34.530	39.600
Feed Gas Rate *mmscftd*	2,000		3,000		3,500	

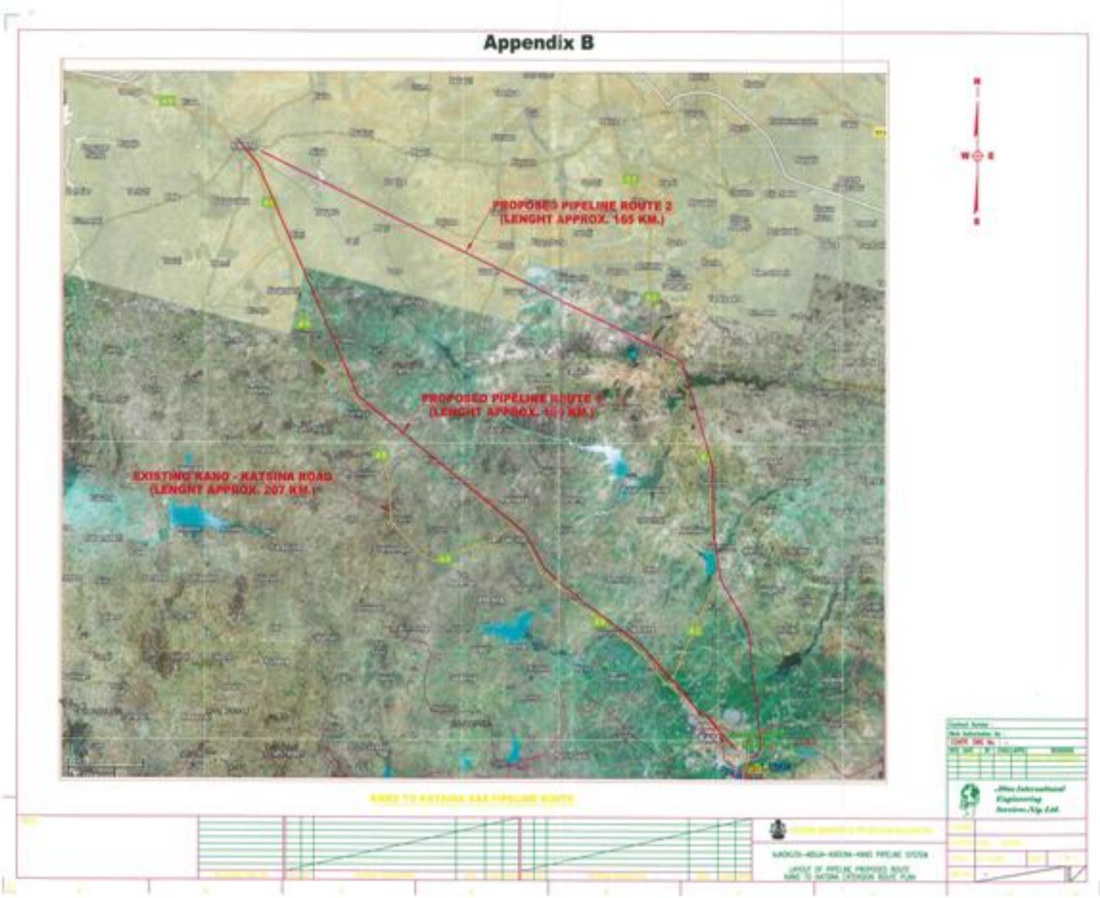

FIGURE 1: Aerial view of Right-of-Way and Mapping from GPS

III. BACKGROUND TO THE PROJECT CONCEPTUALIZATION.

The need to increase productivity through industrialization using gas resources became imperative following the privatization of NAFCON, ASCON, AJAOKUTA STEEL MILL and some of the Petrochemical plants between 1998 – 2000. Most of these plants uses natural gas as feed stocks. Besides, there was also an enormous need to increase power generation for industrial and domestic use. These and many other factors trigger the need for pipeline network that would transport natural gas from areas of abundance to areas of scarcity in the country, essentially for industrial spread of development industries. However, the field activities that must be performed at the end of the stated periods for an expected 85% completion and 90% efficiency and maintenance service of gas compressor at ALAKIRI GAS PLANT-ONNE needed to be scheduled. Such activities must be arranged to suite the CPM method and as shown in table 1. The sequence of all activities involved can be confusing and time consuming. However, since CPM is activity oriented and deterministic model, it suits the integrated approach needed to meet the target for the conceptual design to the gas pipelines. The conceptual framework was initiated.

There exist compressor designs with gearbox transmission system as a starting point. Hence, the need for a simple easy to maintain design that will use the pulley-chain power transmission system. Management decision specified a time frame within which all design, fabrication, installation test run and full operation will be achieved. High safety standard needs to be maintained and so, the safety inspectors needed to provide and ensure that personnel protective equipment (PPE) are put on for any given activity. The design engineers and maintenance crews need to have the right and adequate tools and materials for proper man-hour utilization and experience ones assigned to carry out the activities to obtain high efficiency. The management team needed to ensure regular and timely releases of funds for operation services while the technical services department needed to ensure that activities are performed in accordance with design specification and standards. The conceptual design study specification based on the job scope is as shown in table 2.

TABLE 2
COMPOSITIONAL AND PRESSURE DESIGN PARAMETERS

	BIDDERS INFORMATION:		CONCEPTUAL DESIGN STUDY:		CONCEPTUAL DESIGN STUDY:	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Major and Minor Components, mole%						
Methane	80.45	81.64	75	-	80.45	87.68
Ethane	5.91	6.08	-	10	6.08	6.46
Propane	3.67	3.77	-	5	0.61	3.67
Butanes	2.42	3.04	-	2	0.13	3.04
Pentanes and heavier	1.6	1.83	-	0.5	0.07	.83
Nitrogen and other inerts	0.69	0.73	-	4	0.73	0.73
Carbon Dioxide	3.97	4.2	-	4	4.2	4.32
Other Characteristics						
Pressure psig	1,000	1,000	1,250	1,000	1,250	
Gas heating value, KJ/Nm^3	37.750	42.840	35.400	42.800	34.530	39.600
Feed Gas Rate *mmscftd*	2,000	3,000	3,500			

IV. DESIGN CONSIDERATIONS

The need to reduced flare gases in the country harnessed and channeled it through the Trans- Nigerian Gas Pipeline Projects into the West African Energy Hub in the regional gas network for both domestic and industrial development form the main design basis for the project. The steps taken to actualize the concept is as discussed below:

4.1 Codes and Standards

The applicable Codes, Standards and Regulations for the Calabar – Umuahia – Ajaokuta, Ajaokuta – Kaduna - Kano – Katsina trunk lines were design in accordance with the Conceptual Design Specification as contained in Study Report (Ministry of Petroleum Resources, 2010. – AAK-009-SP-10-0002).

Pipelines and terminal facilities envisaged were also designed and engineered primarily in accordance with the provisions of American Standards for Measurement and Evaluation (ASME) B 31.8- 2007: Gas Transmission and Distribution Piping Systems. In addition, the following codes/standards were complied with to ensure safety and sustainable pipeline longevity in the national gas transmission scheme (Neeka, Busari and Jones 2010; Ministry of Petroleum Resources).

ASME B 31.3 Chemical Plant & Petroleum Refinery Piping

API Std. 1102 Steel Pipeline Crossing Railways & Highways

API Std. 1104 Standard for Welding Pipelines and Related Facilities

It is envisaged that the Kano tie-in point shall be an underground, welded joint most likely identical to the preceding upstream joint. The Kano Terminal Gas Station (TGS) spur line and tie-in location to be determined after the Right Of Way (ROW) survey completion. However, allowances were made for possible design variance. The fourth booster station is likely to be similar to the preceding upstream booster station; again its exact location was to be determined after the completion of the process simulation. Pipeline engineers were expected to determine the number of additional Line Break Valve Stations (LBVS). The construction of the additional LBVS are similar to the other upstream LBV stations in the country. Such categories like above ground Motor operated Valves, unmanned real time all year round with security personnel strategically stationed for surveillance. The main booster station with the Central Control Room is unchanged; the Abuja Booster Station. The proposed heavy-duty construction road alongside the proposed ROW is to be extended to link lines in Port Harcourt and Katsina respectively. It is also envisaged that two additional construction campsites with specified land dimensions will be acquired for the entire project line.

V. BASIS FOR THE ENGINEERING DESIGN SERVICES

After the initial conceptual project team meeting, personnel composition and preliminary activities, proper and adequate geographical survey to map the exact location of the old Right of Way and the proposed new Right of Way (ROW) were fundamental to the actual design process. This aspect of the overall exercise was carried out on all front and detailed reports submitted to the initiator of the project (Emmanuel, Innocent and Chukudi;2010,). Following the approval of the new ROW map, a new Environmental Impact Studies were carried out and completed, which latter form together with the ROW map the basis of the scope of work defined by the project supervisory team.

5.1 Scope of Work

Complete design for the EPC tender bid, including:

- Environmental Impact Assessment (EIA) Report
- Front End Engineering Design (FEED)
- Detailed Engineering Design (DEED)
- Construction scoping
- Hazard Operability (HAZOP) and IPF reviews
- Constructability review
- Class 3 cost estimate
- Invitation to Bid (ITB) documentation

For the construction of dual gas pipeline between Kano and Katsina.

5.2 Design Data and Parameters

Pipeline Systems for CUA and AAK have about eignteen (18) major river crossings and 20 major road crossings. Calabar → Umuahia →Ajaokuta (681km) and Ajaokuta→Lokoja→Abuja→Kano. (585km) respectively.

The design parameters are similar to all existing pipeline project data:

Feed gas condition at terminal points	pipeline quality dry gas
Maximum feed gas flow	3,000 mmscftd
Kano TGS sale gas flow	500 mmscftd
Required minimum sale gas pressure at extension	1,000 psig
Distribution pressure at all three (3) TGSs	350 psig
Maximum compressor discharge pressure at	
Booster stations	1,250 psig
Pipeline construction buried, twin, insulated	
Estimated length of PH – OB – OB and Kano-Katsina pipelines 168km and 160 km respectively.	
Main trunk line size	48 inch
Spur lines size at TGS	22 inch
Total No. of compressor booster stations	Nine (9)
Total No. of terminal gas stations	Seven (7)
Design life	25 years

The new pipeline is supplied with pipeline quality gas at a minimum pressure of 1,000 psig at Calabar and Ajaokuta tie-in and delivers to Kano also at a minimum pressure of 1,000 psig. In order to overcome transmission losses and enable selection of an economic pipeline diameter, a number of Compressor Booster Stations will be required at intermediate locations along the pipeline route. Spur lines will link the main pipeline with Terminal Gas Stations at Port Harcourt, Umuahia, Lokoja, Abuja and Kaduna where the gas will be discharged at a suitable pressure for consumer distribution and fiscally metered (Neeka et al 2010).The pipeline is sized for an ultimate design capacity of 3,000 mmscftd. The Odukpani, Port Harcourt, Abuja and Kaduna spurs shall be sized for 500 mmscftd each leaving up to 2,000 mmscftd available at Ajaokuta and Kano for local distribution and export to the future trans-Saharan pipeline system.

5.3 Identified constraints

It has become apparent that the Port Harcourt – Obenyi – Obirikom (PH – OB – OB) and Kano – Katsina Extensions will necessitate alteration of the original design specifications to accommodate several Tee-offs into the expected gas plants, gas farms and fertilizer plants. Enough gas supply from the various producing companies including international oil companies must be sustained for the actualization of the projects. Most notable among these constraints are the right of way, understanding of the pipeline design concept, job scoping taking cognizance of the varied specification need at various points, projections and proper forecasting of the future utilization of gas resources from unforeseen industrial concern, environmental impact assessment studies etc. These constraints are fundamental to the actual completion work on Calabar – Umuahia – Ajaokuta and Ajaokuta – Abuja – Kaduna – Kano gas pipeline system documents to be revised and re-issued by the supervisory Ministry. The following type of documents would have to be revised for the seamless procurement and construction of the gas pipeline system to commence as planned (Busari et al 2011).

- Process engineering design documents
- Piping and pipeline engineering documents
- Control and Instrument engineering documents
- Civil engineering documents
- ROW mapping

- Cost estimation

In addition, the following submissions were expanded and resubmitted with all the relevant conceptual design provisions in accordance with the standard operational manual developed for the project (Neeka et al 2009).

- Terms of Reference document
- Environmental Impact Assessment
- Permit to survey applications

VI. MATHEMATICAL MODELS ON PROJECT NETWORK ANALYSIS

There are several pipeline designs sequences and different approaches that can be adopted to ensure effective project management and production optimization. However, to identify all events using the Critical Path Methods involving early start, early finish, late start and late finish is important on a time scale work schedule. These events were scheduled and evaluated in accordance with equations (1) and (2), and the estimated results are shown in Table 1. The fundamental assumption is that the activity items are estimated as single point estimate independent of each other. Besides, time - cost trade-off for the project and duration of one activity is assumed to be linear relative to the cost of resources applied as shown in the equations below:

$$TF = LTF - LTS - D \tag{1}$$

$$FF = ETF - ETS - D \tag{2}$$

Where; TF is the Total Float and FF is the Free Float, LTF, ETF and ETS are Late Time Finish and Early Time Finish, LTS are Early Time Start and Late Time Start respectively and D is the duration of activity.

Similarly, available literature shows that the percentage completion (% completion), predicted final hours (PTF.hrs), and performance efficiency (PERF) through the value hour method can be determined as shown in equations 3-5. Further references on the application of these principles in the determination of work break down scheduling and activity dependent sequencing in project implementation could be explored in the works of Robert S. Avies (1955), Max S. Peters (1980), Abam (1998) respectively. Also, application of estimated design values needed to apply to the entire trunk lines and the suitability in these equations were determined according to the following:

$$\text{Completion} = \frac{VA.hrs}{BT.hrs} \times 100 \tag{3}$$

$$\text{PTF hrs} = \frac{ACT.hrs}{\%completion} \times 100 \tag{4}$$

$$\text{PERF} = \frac{VA.hrs}{ACT.hrs} \times 100 \tag{5}$$

Where; VA.hrs is the Value hours, BT.hrs is the Budget hours and ACT.hrs is the Actual hours respectively.

Activity sequencing requires the determination and documentation of the relationship between other activities with respect to completion time. The CPM and SMAC methods are typically used in the precedence diagram to structure such relationships. Sequencing usually begins with the chronological ordering of activities, based on the logical progression of events. Activity definition requires the combination of the scope document, and the utilization of the work break down structure to develop discreet activities that are unique and be associated with deliverability

$$A_D \times Q_I = O_D \tag{6}$$

Where A_D represents the Activity of Duration, Q_I represents the Quantity of an item and O_D represents the Overall Duration.

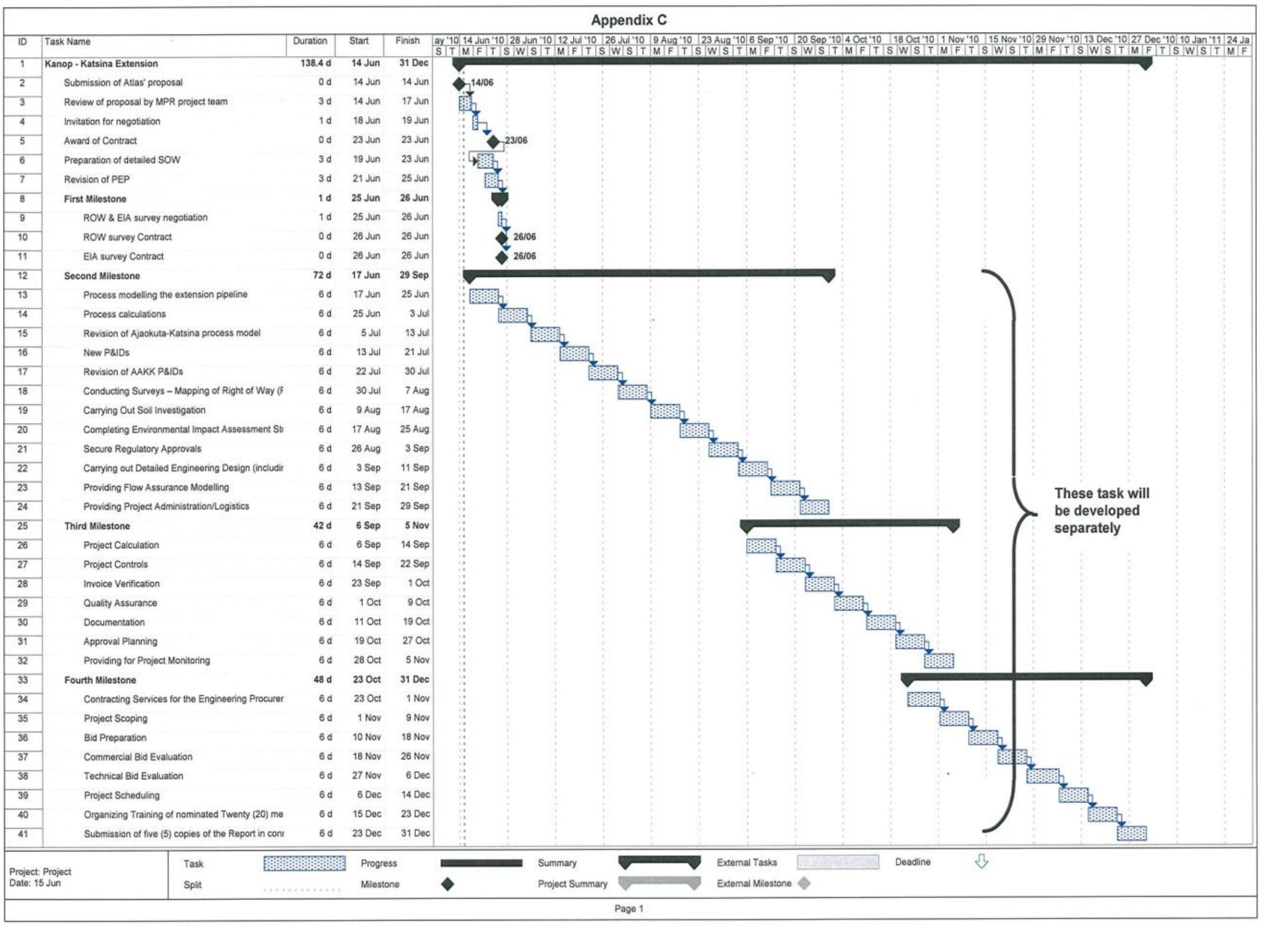

FIGURE 2: Example of the Work Breakdown Structure Analysis

TABLE 3
PIPELINE PARAMETERS

Pipeline Design Parameters	
Description	**Value**
Pipeline size	60 inches
Pipeline size	24 inches
Design Pressure (Psig)	1235
Operating Pressure (Psig)	1000
Max. Design Temperature, °C i. Above ground section ii. Underground section	 65.0 45.0
Operating temperature, °C	25-45
Economic Design Life, years	100
Corrosion Allowance, mm	3

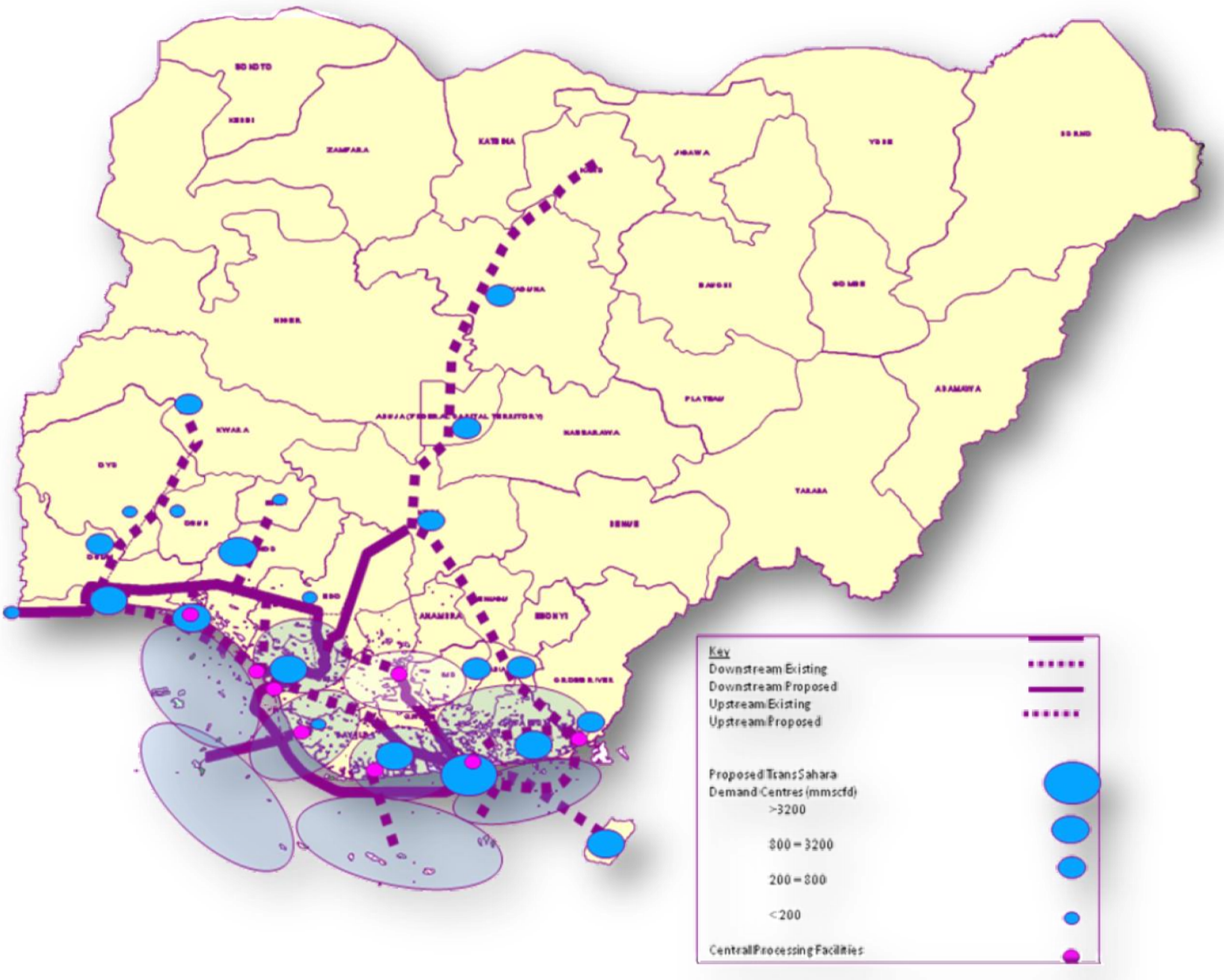

FIGURE 2: Map of Nigeria showing the gas source in Okopedi, Calabar

VII. CONCEPTUAL MANAGEMENT STRUCTURE.

Various management structures on the Trans- Nigerian Gas Pipeline Projects were design to actualize the initial conceptual plans. Some of the structures became complex and constitute sources of delay in the implementation strategy. Such structures include: the project planning and implementation team; monitoring and evaluation committee; procurement planning and implementations team; technical review and reporting team; inter-ministerial supervisory committee; stakeholders forum committee etc. These structures were subject to periodic review and were mandated to inter-phase with the appointed consultants. The office of the technical assistant to the Permanent Secretary took full responsibility for the proper and adequate reporting on the project to top ministry management and to the minister through the permanent secretary (Neeka, 2010). However, the details of the following activity-based teams are fundamental in the conceptual management structure.

7.1 Project Planning and Schedule

The project schedule is an integral part of a detail cost estimate. The duration of a project affects the cost through the period dependent cost, and the selected technology for the activity-dependent work and associated costs, affects the schedule. The activity dependent schedule is drawn from the cost estimate database to establish durations for each of the activities in the schedule. Hence, the activity duration multiplied by the quantity of an item in the planned invention list provides an estimate of the overall duration to perform the activity. The number of man hours multiplied by the quantity of an item in the same planned inventory list equally provides an estimate of the overall manpower resources to perform that activity. The cornerstone of project planning and schedule preparation and development is a formal documented scope. The content of a formal written scope statement should spell out the expected activities and duration in the plan. Activity sequencing requires the determination and documentation of the relationship between activities. The CPM and SMAC methods are typically used in the precedence diagram to structure the relationships between activities. Sequencing usually begins with a chronological ordering of activities, based on the logical progression of events. Activity definition requires the combination of the scope document, and the utilization of the work break down structure to develop discreet activities that are unique and be associated with deliverability

7.2 Evaluation and Optimization of Critical Paths.

This is a critical decision, and if the proper level of detail is not selected it could cause the entire project team to ignore the schedule. If the schedule is prepared at too fine a level, the project runs the risk of being overwhelmed with data that inevitably the project control staff is unable to maintain. On the other hand, a schedule with too little detail is insufficient to use in tracking progress, anticipating problems or developing risk strategies. There is need to schedule activities at the level that can control the work. This may be somewhat judgemental and is dependent on the skill of the project team, its experience, the complexities of the activities and the risk involved in each activity.

The critical path is the longest sequence of activities in the work process flow chart. The critical path controls the overall length of the project. Any incremental change to the critical path activity will result in a corresponding change in the overall schedule. Hence, the critical path method was adopted to evaluate and determine what technological changes needed to be inputted into the overall project scoping. Parallel path changes or duration estimate changes can be made to shorten the critical path where necessary. The overall schedule duration is one of the major cost driven forces in a project management technique. Once adopted, it is obvious that the schedule could serve as baseline schedule to the project. It is against this schedule that project performance will be measured. It is also possible to develop these sequences into a software package, which this paper will not address now. The last phase in the development of the cost estimate and schedule is to assign the cost elements to the work breakdown structure. Typically, the work breakdown structure is used to collect and monitor costs of the program. At the owner license discretion, the baseline may be adjusted periodically to account for changes in scope of work funding constraints, or schedule changes as a function of acceleration or delays in the project.

VIII. WORK BREAKDOWN STRUCTURE AND DISCUSSION ANALYSIS

The conceptual framework on the Trans -Nigerian Gas Pipeline Projects started with the fundamental process of advertisement. For ease of planning, some activity items were executed concurrently to ensure on-time delivery. The shortlisted applications for the needed consultants were pre-qualified for bid tendering. At the end of contract award process for the consultants, formal kick-off meeting and documentation stating the project scoping is completed. Milestone project execution starting with preliminary design, conceptual design and impact assessment is carried out (see Tables 1 and3). Several review processes are carried out simultaneously to ensure that all concepts and terms are complied with accordingly. It is also important to note that various activities slated for execution at the milestone level remained valid as planned if and only when the parties involved agreed to follow and comply with the project timetable. Thus in the execution of the Trans Nigerian Gas Pipeline project, it was the responsibility of the supervisory Ministry to ensure compliance to the project timeline with the collaboration of the project consultants' and the internally constituted project monitoring team made up of experts in the various aspects of engineering, environmental and safety management respectively. Community concerns and compliance with surveyed right of way were critical to the timely completion of the project (see Fig.1) Approval planning, invoice verification, quality assurance and control, training and manpower development as well as final report submission and close out are largely fundamental to the actual completion of the phases involved in the execution processes.

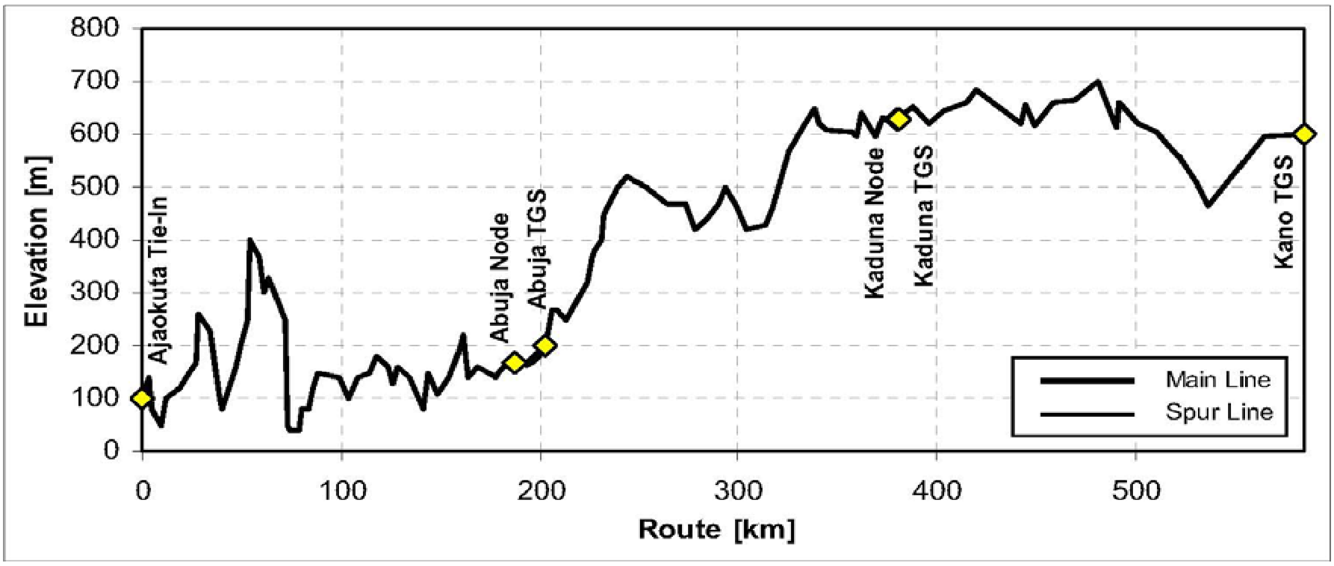

FIGURE 3: Pipe design simulated elevation

TABLE 3
ACTIVITY DEPENDENT SCHEDULE OF A PROJECT PLAN USING SMAC METHOD.

ACTIVITY OR MILESTONE	DATE	REMARKS
Project advertisement appeared	06-Apr-2009	Completed
CONSULTANT Pre-qualification	26-Apr-2009	Completed
Tender Bids issued	27-Apr-2009	Completed
Preliminary route survey completed	25-Jun-2009	Completed
Bid closing date	10-July-2009	Completed
Pre award clarification meeting	12-Sept-2009	Completed
Contract award	02-Nov-2009	Completed
Project Execution Plan submission	12-Nov-2009	Completed
Kick-off Meeting	12-Nov-2009	Completed
Submission of Terms of Reference for EIA Report	18-Nov-2009	Completed
Draft Front-End Engineering Design Report completed	03-Dec-2009	Completed
Conceptual Design Report	03-Dec-2009	Completed
Outline of EIA studies	03-Dec-2009	Completed
Milestone 1	05-Dec-2009	Completed
Detailed Engineering Design Project Execution Plan Submission	07-Dec-2009	Completed
Mapping of Right of Way Survey	12-Dec-2009	Completed
Soil Investigation	12-Dec-2009	Completed
Environmental Impact Assessment Studies	12-Dec-2009	Completed
Initiate Securing Regulatory Approvals	12-Dec-2009	Completed
Commencement of Detailed Engineering Design	12-Dec-2009	Completed
Commencement of Flow Assurance Modelling	12-Dec-2009	Completed
Milestone 2	14-Dec-2009	Completed
Revised Gas composition received	05-Feb-2010	Acknowledged
Scope of Work Revision received	06-Feb-2010	Acknowledged
HAZID Workshop	12-Feb-2010	Completed
Area I flyover of ROW	13-Feb-2010	Completed
Monitoring team from MPR working in Consultant’s office	17-Feb-2010	Completed
Project monitoring by Royal Cat Int’l Ltd	02-March-2010	Completed
Project monitoring by Otis Engineering	05-March-2010	Completed
HAZAN Report	14-March-2010	Completed
Approval of Front-End Engineering Design	14-March-2010	In progress
Approval of Flow Assurance Modelling	14-March-2010	In progress

IX. CONCLUSIONS AND RECOMMENDATIONS.

Gas resources and rapid development of its infrastructures such as the Trans-Nigerian Pipeline Network are fundamental to the increasing transformational needs of the country. Industrial parks and effective domestication of gas utilization can only strive where there are efficient and sustainable gas pipelines of high integrity. The concept of designing, procuring, constructing and commissioning a Trans-Nigerian Gas pipelines from Calabar through Ajaokuta to Kano is critical to economic and human capacity development. Several businesses and industrial concerns were anticipated with strong policy to increase job creations and reduce the number of unemployed in the labour market through new established industries and serving agencies along the pipeline network routes. For ease of administration of the complex projects and as a globally acceptable standard, critical path methods and site man-hour cost control evaluation strategy were applied. This strategic instrument applied in the process conceptual design from start to finish was fundamental to the successful determination of the key performance indicators in the project. The critical path method and site man-hour cost control applied to project management had rigorous project scheduling and milestone evaluation standards. It is the road map that outlines how the project will move from engineering concepts, to completion and site restoration. As a tool it also supported different purposes for different members of the project team. For the Engineer, it provided information on what needs to be done, when it needs to be done, and what other activities may affect the start and completion of his work. It provided a measure of performance evaluation. With the successful completion of the detailed engineering design, documentation and training of the stakeholders on the project, it is recommended that the actual processes of procurement for construction should commence without delay, knowing the overall national benefits that would ensue. Inter-agency politics should be avoided for the interest of the nation and its citizens and the need to Fast Track the development of the nation’s gas resources and its critical infrastructure such as the gas pipelines. It is strongly suggested that the Ministry of Petroleum Resources should be funded to complete the procurement processes using the qualified strong workforce available in the Ministry along with selected consultants. Other stakeholders such as the Nigerian National Petroleum Corporation and the Department of Petroleum Resources should also contribute expertise and technical supports for the actualization and realization of the projects. The rapid growth of Nigerian oil and gas sector through gas utilization and sustainable assets such as pipeline network should attract tax holidays from the government in power to companies involved in construction and commissioning of the projects. Nigeria gas pipeline system document and treated as one complex publication. After the merger, terms and references to all the extensions on the gas pipeline system will be replaced with the new contractual terms. The Gas Pipeline System term in all design documentations and the Procurement and Construction Bid Packages, except for the commercial Milestone Schedule will be further reviewed. At this point, all document containing the conceptual designs and documentation had been completed for use by the supervisory Ministry. It is expected that the original contractors will continue to work with the Ministry of Petroleum Resources to actualize the contractual Milestone Schedule and deliver on the construction of the gas pipelines for the benefit of Nigerians and the stimulation of industrial growth respectively. Further submission for extension of time and additional fund to cover scope changes could also be negotiated where possible (Neeka et al 2010). With the Port Harcourt – Ob – Ob and Kano – Katsina Extension submissions, a new Milestone Schedule is proposed, and it shall be treated separately and parallel with the new Milestone Schedule. In addition, as a separate document with the details of Cost-Time-Resources estimate workout sheets developed, further review and assessment by the Ministerial Project Control Team is important to ensure quality procurement processes. Overall, critical review of the past design data and information is imperative for the actual commencement of the next phase of engineering procurement. Selected management consultants and experts should be engaged for the effective management of the projects. Gas policies should be strengthened to place more emphasis on domestic utilization rather production for exports that is currently the practice. More sectorial collaboration including gas to power, renewable energy gas utilization plan involving the power sector, environment, agriculture and petroleum etc should be worked out strategically.

REFERENCES

[1] Abam, D.P.S. (1997); Applied Engineering Management. University publications limited, Lagos-Nigeria.

[2] BusariKamaru and Jones Ogwu (2011): Review of the Consultant’s Reports on the Trans- Nigerian Gas Pipeline Projects (Calabar – Umuahia – Ajaokuta and Ajaokuta – Abija – Kaduna – Kano). July 2010.

[3] Chukwudi B, Innocent C and Emmanuel G (2010): Reports on the Soil Tests and Mapping of Right of Ways on Calabar-Umuahia-Ajaokuta and Ajaokuta-Abuja-Kaduna-Kano gas pipelines Projects. Ministry of Petroleum Resources, NNPC Towers Abuja.

[4] Neeka Jacob, Jones Ogwu, Emmanuel Ezuegbu, Elizabeth Umoren (2009): Draft Manual on Standards for Operations and Activities for the Nigerian Gas Pipeline Projects. Ministry of Petroleum Resources, Block D, NNPC Towers, Abuja Nigeria, PP 6-10.

[5] Neeka Jacob Biragbara (2010): Brief Report of the Technical Assistant to the Permanent Secretary, Ministry of Petroleum Resources at the 17th management Meeting on the Trans- Nigeria Gas Pipeline Project. Block D, NNPC Towers, 6th Floor, Central; Business District, Abuja.

[6] Fubara, B.A. (1998) Project planning and Evaluation. A synthesis-Seabross international press Nigeria.

[7] Idoneboye, K.I. (2004) Optimization; Project Management in a Chemical Super Project (soap and detergent manufacturing) inaugural lecture series 11, RSUST Port Harcourt.

[8] Iyagba, E.T. (2004) Mathematical Modelling for Engineers and scientist. Unpublished lecture note, University of Port Harcourt.

[9] Neeka Jacob, BusariKamaru and Jones Ogwu (2011): Performance Evaluation on Milestone achievements of Ministry's Consultants; Trans – Nigerian Gas Pipeline Projects. November 2010.

[10] Chi U.Ikoku, 2004: Handbook on Gas Engineering; University of Port Harcourt Publishing House, Choba, Port Harcourt, Nigeria.

[11] Max, S.Peters and Klaus, D. Timmerhaus (1968); Plant design and Economics for chemical Engineers. Mcgraw Hill Inc. London.

[12] Jones Ogwu (2009): Project Conceptualization and Scoping on the Trans – Nigerian Gas Pipelines; Reports on the Kick- Off Meeting on the CUA and AAK Trunk Lines. December 2009. Ministry of Petroleum Resources, NNPC Towers Abuja.