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STRATEGIC MANAGEMENT STRUCTURE IN NATURAL GAS RESOURCE DEVELOPMENT: THE TRANS-NIGERIA GAS PIPELINE SYSTEMS.

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ABSTRACT.
National energy policies, politics of climate change and the environment affect energy supply chains and energy access, known to be proportional to rapid economic growth and industrialization drive of both developing and developed nations. While energy access is critical to sustainable development, the resources that provide links to direct access are in limited supply all over the world. Natural gas resources are one of the cleanest sources of energy and are also in high demand but limited in supply. Moreover, gas infrastructure such as pipeline networks, storage facilities are not readily available neither is the cost of construction, operation and maintenance affordable. The changing climatic conditions and environmental variance also contribute to the challenges of making gas resource and infrastructure accessible. Most of these challenges and other factors are consequences of established Management structure. In this paper, gas infrastructural development for enhanced industrialization was examined to determine the effectiveness and compliance level of government policy implementation. Strategic Management policies for the initial design, contract procurement, construction and commissioning stages were statistically analysed from hands-on real time data. A historical review of previous gas infrastructure and pipeline networks in the country were undertaken to ascertain the parametric design data. The Calabar – Umuahia – Ajaokuta (CUA) and the Ajaokuta – Abuja – Kano (AAK) are two streams of the Trans-Nigeria Gas Pipelines for transporting natural gas from areas of high concentrations to areas of high demands in the country. It was established that policy fluctuation, funding releases, dearth of in-country manpower and topological variance contributed substantially to the inconclusiveness of the Trans-Nigeria gas pipeline project for over a decade. This paper is therefore useful for decision-making and policy formulation on gas development.

Key words: Trans-Nigeria Pipelines, Strategic Management, Natural Gas, Government Policies, Industrialization and Economic Development.

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). In addition, the recent shale revolution in the USA has increased the importance of gas as an energy source.

The Trans – Nigeria Gas pipeline projects were conceptualized to accelerate domestic gas utilization 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 187TSCF. Gas pipeline projects across the globe have been a source of massive income for the country of origin as well as those desiring to use it 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 proposals 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. This approach has been adopted in several test cases to address the question of how soon the project will be completed, when is each individual phase of the schedule to start and or finish, which are the critical phases of the project to be finished on time, what are the cost implication and, how efficient is the performance at the end of the stated period.

The gas compressor needed for oil industries in Niger Delta comes in different design and always complex to assemble for effective maintenance. The oil industry is also dynamic, and competition and efficiency call for the adoption of 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 equally high. 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 optimum rate and safe environment.

This is the focal point on which CPM and SMAC found its relevance in the project optimization of compress gas in the oil industries in the Niger Delta. 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.

REVIEW OF EXISTING GAS PIPELINES IN NIGERIA

Nigeria is described as more endowed with gas resources than oil, with over 198 trillion cubic feet in 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 according to the Nigeria Gas Master Plan publication (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 (OB3) 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

BACKGROUND TO PROJECT CONCEPTUALIZATION.

The field activities that must be performed at the end of the stated weeks for an expected 85% completion and 90% efficiency is obtained from the test run and maintenance service of a centrifugal gas compressor at ALAKIRI GAS PLANT-ONNE. The orders of activities are arranged to suite the CPM method and as shown in table 1. The sequence of all activities and parties 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.

There exists a centrifugal compressor design with gearbox transmission system. This type of compressor with multistage intercooling is noted for high tripping on load resulting from frequent failure of the gearbox. Hence, the needs 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 need 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 need to release fund for operation services while the technical services department need to ensure that activities are performed in accordance with design specification and standards maintained.

DESIGN CONSIDERATIONS

It is envisaged that the Kano tie-in point is going to be an underground, welded joint most likely identical to the preceding upstream joint. The Kano TGS spur line tie-in location to be determined after the ROW survey completion, but allowance has to be made for that. The fourth booster station is likely to be similar

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to the preceding upstream booster station, again its exact location to be determined after the completion of the process simulation. Pipeline engineers are to determine the number of additional Line Break Valve stations. The construction of the additional Line Break Valves are very similar to the other upstream LBV stations, i.e. above ground Motor operated Valves, unmanned by operation, but provisioned by 24/7, all year round security personnel. The main booster station with the Central Control Room is unchanged, i.e. 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 (2) additional construction campsite joint with lay down area will be required for the entire project line.

Table 1: Conceptual Design Parameters of a Typical Gas Pipeline.

	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 inert gases	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	

Fig 5: Map of Nigeria showing the gas source in Okopedi, Calabar.

ISSN: 2714-2264

BASIS FOR THE ENGINEERING DESIGN SERVICES

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, Ministry of Petroleum Resources). After 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.

4.1 SCOPE OF WORK

Actual project scoping and term-based definition of gas pipeline parameters are fundamental to complete design for the EPC tender bid. Such terms and parameters include:

- 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

4.2 DESIGN DATA AND PARAMETERS

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

Table 2: 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

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

Feed gas condition at terminal points pipeline quality dry gas

African Journal of Engineering and Environment Research Vol.7(1) 2025 pp 87 - 101

ISSN: 2714-2264

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 pipeline	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.

5.0: 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 and create the needed local contents,(Neeka et al, 2023). 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. The value additions from the project work break down is designed to transform the gas infrastructure needs of the country along the pipeline corridors.

$A_D \times Q_I = O_D$.. (6)

Where AD represents the Activity of Duration, QI represents the Quantity of an item and OD represents the Overall Duration.

5.1: 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 any critical path activity will result in a corresponding change in the overall schedule. Hence, the critical path method has evaluated to determine what technological changes. Parallel path changes or duration estimate changes can be made to shorten the critical path. 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 software package, which this term paper is not in any position to 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.

5.2: WORK BREAKDOWN STRUCTURE.

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. 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 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. 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. Details of the work breakdown structure is as shown in the chart below:

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Table 3: Activity Dependent Schedule 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

6.0: CONCLUSIONS AND RECOMMENDATIONS.

Gas resources and rapid development of its infrastructures such as the Trans-Nigerian Pipeline Network are fundamental to the increasing transformational need of the country. Industrial parks and effective domestication of gas supply obligation can only strive where there are efficient and sustainable gas pipelines of high integrity. The concept of designing, procuring, constructing and commissioning a 56” Trans-Nigerian Gas pipelines from Calabar through Ajaokuta to Kano is critical to economic and human capacity development. Critical path method and Site Man-hour Cost Control have rigorous project scheduling and milestone evaluation standards. 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. 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 or 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.

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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 training 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 flared gases in the country should be harnessed and channelled through the Trans- Nigerian Gas Pipeline Projects into the West African Energy Hub in the regional gas network called the Trans-Saharan Gas Pipeline Projects. 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.

Table 4: Activity and Milestones Progression

ACTIVITY OR MILESTONE	DATE	REMARKS
Project Management including	14-March-2010	In progress
Project Controls	14-March-2010	In progress
Invoice Verification	14- March-2010	In progress
Quality Assurance	14-March-2010	In progress
Documentation	14-March-2010	In progress
Approval Planning	14-March-2010	In progress
Milestone 3	14-March-2010	In progress
Prepare ITT Cover/Instructions for Detailed Engineering Design	30-Sep-2010	In progress
Complete selection cycle of Detailed Engineering Design	30-Sep-2010	In progress
Detailed Engineering Design	30-Sep-2010	In progress

Figure 1: Aetial View of the Right of Way of Pipelines.

African Journal of Engineering and Environment Research Vol.7(1) 2025 pp 87 - 101

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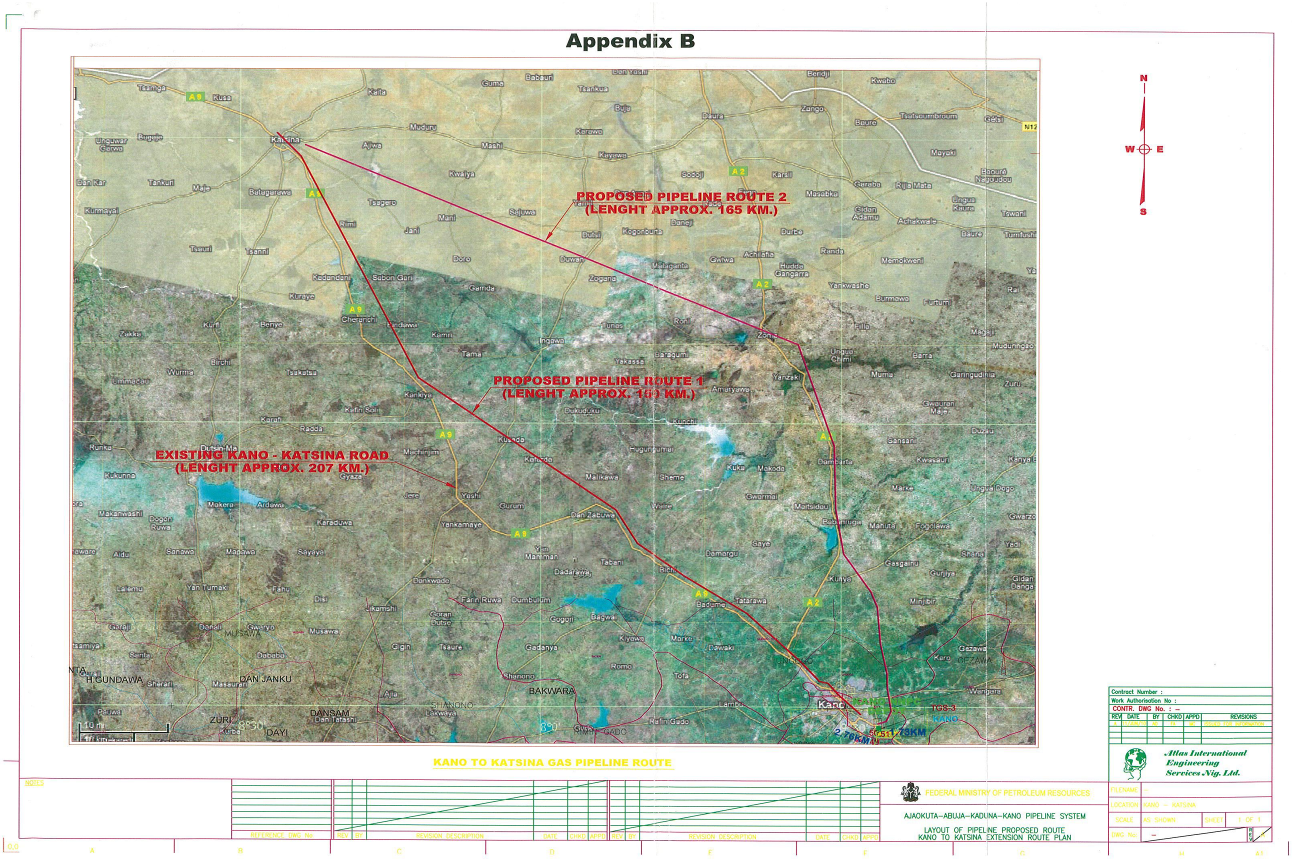

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