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Proposal Laying Fiber Optic for Cables along Railways Tracks in Sudan

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Abstract: *Fiber optics cables offers various advantages of over regular cables when used as data transportation medium in today's communication networks. Many African countries such as the Sudan and South Africa large portions of their land connected through railway networks. Remote areas in such countries are scarcely connected to communication networks other than use of mobile phones communications relying on microwave or satellite communications. Such communications are expensive and inefficient. In this study, a proposal to use the railway networks for establishing fiber optic networks for communication purposes to connect remote cities and towns. The socioeconomic impact analysis will be provided, and potential issues and obstacles will be discussed.*

Keywords: *Communications, Fibers, Network, Optic*

I. Introduction

The types of mediums used to carry information in today's communication networks are include co-axial cables, fiber optic cables, microwave, and satellite links, copper telephone wires, etc… For long distances, the fiber optics have shown good performance-cost ratios when compared to other means. Examples of fiber-optics benefits includes[1]:

- Immunity to electromagnetic interference,
- Usage of nonconductive materials,
- No electromagnetic radiation from cables leading to high data security
- No current induced sparks risks since no conducting current is used
- Usage of small and lightweight materials
- High operating bandwidth over long distances.

Despite these benefits, the fiber-optic cables suffers from limitations such as[1]:

- Cost where cables are expensive to install but last longer than copper cables.
- Transmission where optical fibers require repeating at distance intervals.
- Fragility where cables are prone to breakage or transmission loses when wrapped around sharp curves. This can be avoided by encasing fibers in plastic sheath wherecables will be hardened towards bending into a small enough radius that could result in fiber breaks.
- Protection - Optical fibers require more protection around the cable compared to copper.

Several countries have laid large fiber optic cable networks along their existing railway tracks. For examples, the British Rail Telecommunications was created by British Rail (BR). It was the largest private telecoms network in Britain, consisting of 17,000 Km of fiber optic and copper cable which connected every major city and town in the country and provided links to continental Europe through the Channel Tunnel[2]. The network infrastructure comprises of transmission systems and telephone exchanges linked by a fiber optic and copper cable network that is located mainly within trackside. Furthermore, the Indian RailTel has more than 42,000 Route Km of Optical Fiber Cable running along Indian Railway Tracks in many part of the country[3].

For sparsely connected countries such in the African continent, transportation authorities have established networks of railways for freight and public transportation. Table 1. Shows sample of African countries with length of railway tracks in Km, where data is extracted from [4] collected between 2010-2014. More information about African countries railway network can be seen in Fig.1.

Table.1 A sample of African countries with Railways track networks and length in KM extracted from [4].

Country	Length of Railways Tracks (KM)
Egypt	5,195
SouthAfrica	20,500
Sudan	4,313

In this paper, a proposal of laying fiber optic cables along railway tracks in Africa railway system is presented. The proposal is discussed with details pertaining to the Sudan geography and statistics, however, the proposal can be applied to many of the African countries sharing similar conditions.

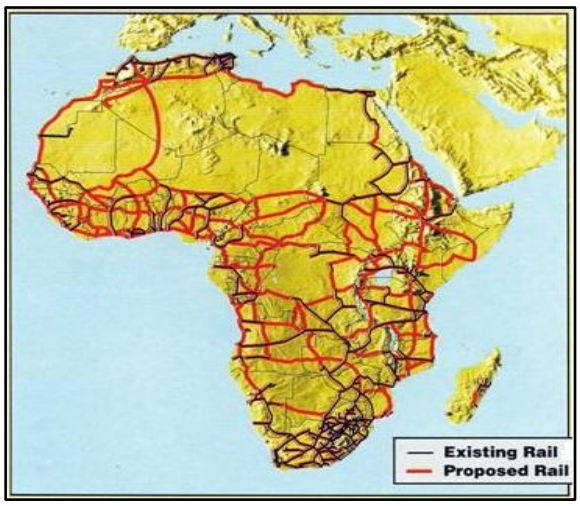

Fig.1 A Map of Existing and Proposed railway networks in African Countries

II. Sudan Railway Network Details

The Sudan Railway Corporation (SRC) operates one of the longest railways in Africa. It operates a 5898 km long single line of 1.067 mm gauge. Construction of the railway lines started in 1897 and most of the track was constructed before 1930. The railway's main route extends from Port Sudan via Atbara to Khartoum with an alternate link between Haya and Sennar via Kassala. There are also branch lines north to Karima and WadiHalfa[4]. Fig.2. shows a map of the Sudan Railway tracks. It can be observed that the tracks covers a wide range of remotely located cities spanning all sections of the country.

The central location of the country and the several geographical neighboring countries from all directions presents the Sudan with an edge over other countries when it comes to connectivity. Railway network reach far to the north, south, east, and west would ease inter-country communication network connectivity. This would add positively to connectivity effort within Africa as a whole. This encouraging fact would be also usable if we consider communication cables laid over railway tracks. The following section propose that notion and list potential benefit and issues.

Fig.2. The Sudan Railways track map showing major cities along the network.

There are various challenges that faces construction of fiber-optics ground cable networks within African countries in particular. Examples of these are:

- high cost of drilling operations to link the cables to remote places
- deliberate damage to cables and equipment with intention of theft and vandalism
- Land permit costs for areas that cable network is established on or passes through
- Adequate training of workers to properly install cables and equipment to prevent operational damages.

Considering these obstacles, the notion of laying fiber-optic cables over an existing railways tracks seem plausible. Table 3. presents a comparison chart between ground cables and rails cables.

Table 3. A comparison chart between ground and rails fiber optic cables

Factor	Ground Cables	Rails Cables
Land Cost	High	NA
Theft/Vandalism	Frequently	Hardly
Security	Vulnerable	Immune
Monitoring	Costly and difficult	Cheap and easy
Repeaters	Standard Power grid	Within Rails Control Rooms
Power	Standard Power grid	Tap into Rails Power
Running cost	High	Standard
Service Continuity	Low	High
Materials	Standard	Standard
Damage	vulnerable	immune
Curved Paths	vulnerable	immune

III. Proposal Of Laying Fiber Optic Cables Over Railway Network

Railroad tracks make good paths for telecommunications cable because they offer cleared, linear routes. In fact, special railroad cars run along tracks plowing cable underground as they move. The cost of assembling such paths for conduits from scratch would be astronomical.

A. Laying Cables Over New Rails:

Fig.3. shows a cross section of how fiber optic cables can be installed when placing new rail tracks. For new construction of railways network or when existing railway tracks renewal efforts it is recommended to plan ahead with adding infrastructure of buried pipes segments that can house the fiber optic cables. It is recommended to place housing pipes in between tracks for enhanced security and safety of cables. The pipes are to be buried close to the surface to simplify maintenance operations. This is suitable for networks with single tracks such as in Sudan case. For networks with dual or more tracks, the spacing between tracks provide potentially good options. A representative example of this is the CRC of Sudan has embarked on a challenging project of renewing tracks of their existing networks for modern and safer tracks. Part of this activity is to lay fiber optic cables for communication purposes.

B. Laying Cables over Exiting Rails:

Fig.4. shows a cross section of how fiber optic cables can be installed within existing rails tracks. Metallic pipes segments that can house the fiber optic cables can be placed within the wood/cement base between the tracks as in Fig. 4. or between tracks where clearance to rail cars would permit as in Fig. 3. It is recommended to place housing pipes in between tracks for enhanced security and safety of cables. The pipes are to be buried close to the surface to simplify maintenance operations. It is obvious that for an existing network the cost and operation would be higher than in the case of establishing new rails networks.

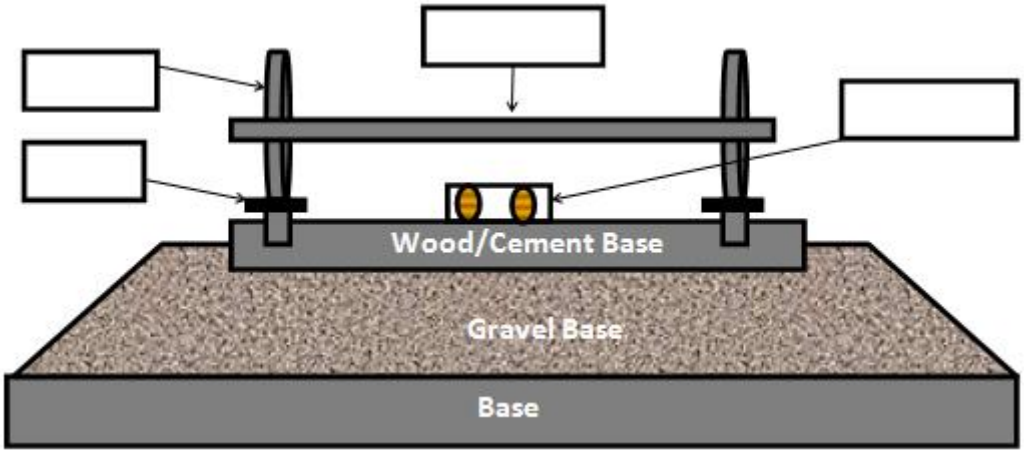

Fig 3. Cross section of wheels on tracks and pipe encompassing Fiber Cables located between tracks

For both situations of existing or new rails networks, the cost of establishing such fiber optic networks along railway tracks is noticeably low compared to digging fresh tunnels to house ground cables. Existing Railways infrastructure such as control rooms can be used to house repeater equipment for cables, and supply power can be extended from existing power network that is supplying railways stations. Repeaters will be required for distance over 100Km, to compensate for attenuation caused by cables. Fiber optic communication network can be utilized in supplying network connectivity to stations, staff, IT infrastructure, and onboard train cars for public transportation travelers.

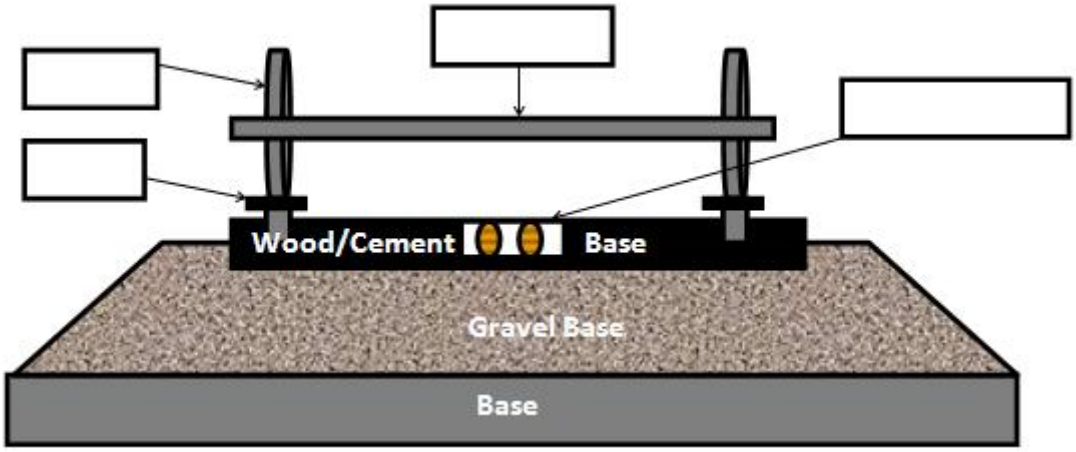

Fig 4. Cross section of wheels on tracks and pipe encompassing Fiber Cables located between tracks

Additionally, laying such cable network would constitute addition revenue source for railways authorities as it can be leased to investors in the communication business. Furthermore, and as in US, railways companies have jumped into the business of supplying connection services to communities for even bigger profits[6]. A good example of this is The Florida East Coast Railroad had been collecting rent from giant telecommunications companies that had buried cable beside its tracks. But between 1999-2000 the company decided to jump directly into the market of selling transmission capacity to telephone companies, wireless services and Internet service providers. The Epik's network covers 80 percent of Florida's population and extends west to Texas and north to Atlanta for revenue in the range of $60 million.

IV. Conclusions

A proposal of establishing fiber optic cable network leveraging existing infrastructure of railways network is presented. The proposal is suitable for countries with exiting or to be constructed new rails networks, such as in Africa where many countries have extensive railways networks that cover vast sections of country lands. Such networks provide cost effective method of connecting remote cities and towns in these countries who rely solely on cellar phone service for communications. Cost of establishing fiber optic cable networks laid over existing, with planned new railways, or renewed railways tracks appears to be lower in cost when compared to regular ground cable networks.

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