Study for the Association of African Universities (AAU) of Optical Fibre for Research and Higher Education Networks in Western and Central Africa

Connecting West & Central Africa to the Global Research and Education Infrastructure

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Executive summary: African universities are severely behind by not being connected to the global research and education infrastructure, in particular W&C Africa

With few exceptions, African universities lack access to the same resources for research and education as their peers on other continents. This is simply due to the fact that they are not connected to the high capacity regional networks such as GÉANT in Europe, providing transit to TEIN in Asia, RedCLARA/ALICE in South America as well as to INTERNET2 and CANARIE in North America, the Global Lambda Interchange Facility (www.glif.is), etc.

This means that research and higher education requiring such access, constituting a significant part of the global research and higher education activities, can currently not be conducted in Africa.

This is not just a matter of improving the connectivity to Internet in general. Transit to Internet is not enough. It is mainly about peering with other research and higher education networks by creating dedicated National Research and Education Networks (NRENs) connecting research and tertiary level education institutions in each African country to a Regional Research and Education Networks (RREN) interconnected to the above mentioned infrastructures on other continents.

At the same price as African universities currently pay for VSAT transit links to Internet only, with low bandwidth and high delay, universities on other continents get dedicated networks with up to 100000 times higher bandwidth, much lower delay and both transit to Internet in general via commercial transit and peering with the dedicated networks established by the global research and higher education community.

ABOVE: The regional research and higher education network in Europe, GÉANT (left), to which all European national Research and Education Networks are connected, provides global links interconnecting all regional research and education networks, including TEIN in Asia, RedCLARA in South America via ALICE and North Africa via EUMEDNET, as well as to INTERNET2 and CANARIE in North America. GÉANT is operated by DANTE (www.dante.net). So far, only a few members in the emerging Ubuntunet in Africa (right) are connected via the SAT-3 link to the Ubuntunet hub in London or, in the case of Kenya, via a tunnel through the KENET commercial VSAT provider. More Ubuntunet members will become connected during 2009. It is important to get West & Central Africa moving rapidly in this direction as well. (Sources: DANTE and Ubuntunet Alliance)

BELOW: the Global Lambda Interchange Facility (www.glif.is) does not yet touch Africa. Only political awareness and will to act on the policy level can change this. (Source: GLIF)
Stakeholder analysis overview - Political awareness and will?

All interviewed stakeholders have demonstrated a positive attitude towards the needs of research and higher level education institutions, including policy-makers in research and higher education as well as in the communication sector, regulators, fibre owners and telecommunication service providers.

We sense, however, that there might exist blocking stakeholders, both among government agencies and among incumbent operators, due to lack of understanding of the importance and nature of RENs or due to perceived or real conflicts of interest.

The difference between Internet access and access to the Global Research and Education infrastructure mentioned above is poorly understood among policy-makers and regulators. The same goes for the understanding that the future requirements of research and higher education institutions are orders of magnitude greater than that of others and cannot be met by bundling them with other public or private user groups. Since our questions thus might have been interpreted differently by different people, some of the responses we have received may have to be interpreted in different contexts.

It is also important to understand that there is a drastic shift involved in all dimensions going from simple low-capacity transit to the Internet using individual VSATs at each institution, to a joint national high-capacity multi-homed network environment with equal shares of academic peering and Internet transit, requiring institutional cooperation on all levels, nationally and regionally.

On other continents, research and higher education institutions are recognised as closed user groups with needs calling for dedicated networks. These institutions are not only capable of building, operating and managing their own networks, but also developing them further, and can thus take advantage of access to more basic infrastructure resources than normal user groups. As a consequence, most NRENS in Europe and North America have opted for access to dark fibre or wavelengths, since such resources are available on reasonable terms on their markets. Standard backbones currently in operation consist of one or more 10 Gbps Ethernet links, often independently routed in ring structures to maximize availability.

Since these networks are strictly non-commercial and only used by a closed user group, they constitute no threat to the commercial market. Instead, they drive the demand for more capacity in commercial applications by training staff and developing applications that migrate into the commercial world.

The regulatory environment seems to be permissive

Our discussions with regulators seem to suggest that neither national nor regional RENs need special licenses, at least not in most ECOWAS member states, provided they are dedicated to research and higher education, strictly non-commercial and lease optical fibre and other network elements from licensed fibre owners. Before the licensing conditions can be analysed in detail and decided by the national regulators, the RENs need to get organized and have well prepared development plans. The structure of the NREN must be tuned to fit the legal
environment and the users nationally, but at the same time fit the international research and education networking community with their demands on Acceptable Use Policy etc.

The issues involved in cross border transit are currently discussed among policy-makers, regulators, operators, donors and financial institutions.

**The necessary physical infrastructure is already available in terms of optical fibre**

Physical infrastructure is not a backbone bottleneck. Our study shows that there is already optical fibre available within and between most countries in West and Central Africa to connect most of the key research and higher education institutions and to interconnect them to other continents. Significantly more fibre infrastructure is not only being planned and discussed but also being rolled out. The fibre maps are changing rapidly.

Infrastructure in terms of optical fibre is already available to build a regional as well as national research and education networks with reasonable coverage of institutions in the region, except in a few countries that are however covered in plans under discussion. The latter category includes the Gambia, Guinea-Bissau, Guinea, Liberia.

**The conditions for access to fibre needs to be negotiated**

The conditions under which access to the available fibre can be granted needs to be carefully negotiated with the fibre owners. Some of the fibre providers approached in the study, especially new entrants as fibre owners and broadband service providers, have declared an interest in discussing win-win agreements with RENs about granting access to basic infrastructure resources that may not be made generally available on the commercial market, provided that the universities prove competent to establish and manage their own networks.

The expected return, in addition to early revenues not removing future commercial market but favourably impacting return on investments and payback time on the fibre investment is market development with socio-economic impact in terms of strictly non-commercial research, education and outreach activities from the universities. Before such negotiations can start, the RENs need to get organized, be able to communicate a clear strategy and vision, and have reasonably well prepared development plans. It is important to not forget a communication strategy relating to the needs and sensitivities of external parties like fibre providers.

**Maturity of the REN formation processes is the first main bottleneck**

There seems to be an awareness and interest among research and education institutions to establish NRENs in most countries included in the study. The concept of an RREN seems also to be reasonably well understood, although there is little experience with regard to how to make the shift from operation of simple low-capacity transit to the Internet in general using individual VSATs at each institution, to a national high-capacity multi-homed network environment with equal shares of academic peering and Internet transit, requiring institutional cooperation on all levels.

In the countries we have looked into, via physical visits or discussions over phone and email, we have seen some of the necessary activities in progress. We have not, however, been able to see documented plans discussing strategic issues, such as visions, policy issues, relations to other African subregions, including EUMEDNET and Ubuntunet, fund raising strategies, national and regional coordination, or project plans with goals, objectives, work break-down into activities, resource requirements, organisation, capacity building plans, stakeholder analyses, fund raising strategies, risk analyses, etc.

So far no formal RREN or NREN organisation is to be found in any country, although there are some processes under way. The champions of these processes need to be identified and supported through the first formation steps. There seems to be no potential NREN member institution that has submitted an application to AfriNIC for the assigned numbers (AS-number and IP address space) necessary to be able to peer with peer institutions on other continents. As bases for such applications it is necessary to map the topology and make an inventory of hosts down to the individual campus network level.

All the REN processes would benefit from guidance for how to establish RENs and coaching in the process. We provide a brief check-list including creating legal bodies, making the abstract design of the networks necessary to apply for assigned numbers from AfriNIC and to discuss licensing requirements with the policy-makers and national regulators, refining the
network design to prepare negotiations with infrastructure owners and make requirement 
specifications for equipment to be procured, formulating Acceptable Use Policies, including 
enforcement procedures and sanctions, defining the organisation for Network Operation 
Centres (NOC), including tools and working procedures, defining the need for capacity 
building of human resources, etc.

We would be prepared to elaborate and get involved in the development of plans as part of a 
capacity building program involving local students and staff from involved research and 
higher education institutions and from other interested stakeholders, as well as resources 
from established NRENs on other continents. These tasks extend, however, beyond this study.

To kick-start, the NREN communities in West and Central Africa should open talks with 
colleagues involved in other African sub-regional efforts, such as EUMEDNET and 
Ubuntunet Alliance, as well as in NRENs in other regional networks in Europe and the 
Americas. Lots of basic structure can easily be drawn from prior work. Significant time can 
probably be saved by cutting and pasting after some initial awareness raising making the 
NREN officials, interim or not, understand why the documents are looking the way they do.

Another consideration is the differences in perspective on who may control or own this 
NREN formation process: Is this a bottom up activity owned and driven by cooperation 
between individuals engaged in campus connectivity, or is it a top down activity with 
initiatives expected from ministry level? In an environment where capacity is scarce and top 
down is the general norm, it is perhaps difficult to initially expect a lot of the local 
engagement that NRENs elsewhere thrive from. Any early NREN process needs at least a 
benevolent recognition from the top, not adding policy uncertainty to all other difficulties.

**Formation of National Research and Education Networks (NRENs)**

On the national level, there are very different scaling challenges. Benin, Burkina Faso, Ivory 
Coast, Mali, Niger and Togo have about a handful of institutions each, while Ghana has up to 
a 100 and Nigeria has up to 500 eligible institutions, including both public and private. This 
calls for coaching of the processes in homogeneous subgroups.

**Formation of Regional Research and Education Networks (RRENs)**

On the regional level, there is a clear lack of communication between NREN communities in 
different countries. In several cases, the involved people have never met or even heard about 
each other. In our opinion the regional process should not wait for the NRENs to materialize, 
but be established in parallel since there will be considerable cross-stimulation. An RREN 
Task Force should be kicked-off as soon as possible.
1. Assignment

This study is commissioned by AAU. The main fibre tracking phase was performed during the period October – December 2008.

The purpose is to explore the feasibility of a phased transformation of the communication infrastructure serving research and tertiary level education institutions in West and Central Africa, from narrowband satellite-based communication to broadband terrestrial communication and linking the region better into the global research and education infrastructure. The analysis is based on a selection of twelve countries in the region and includes:

- Assessment of the requirements from regional and national research and education networks (NRENs) in the region
- Assessment of policies and regulatory frameworks for access to dark fibre in the region and a comparison with other parts of the world, with an emphasis on special arrangements for the educational sector, where such special arrangements exist.
- An inventory of available and planned fibre infrastructure in West and Central Africa, including capacity (number of strands), technical access conditions and a map showing the nodes and paths of the fibre routes.
- Estimation of the present capacity available and used on the SAT-3 fibre infrastructure, current pricing and level of return on investment for the consortium members;

2. Method

The method used includes selection of countries, country analyses, data acquisition and analysis leading to recommendations.

Selection of countries

The selection of countries is based on two criteria: maturity of the NREN process and availability of existing or planned intercontinental links. According to the first criterion, Cape Verde, connected to the Atlantis 2 Cable between Brazil, Senegal and Europe, Cameroon, Ghana, Nigeria and Senegal, all connected to the SAT3 submarine cable, were selected. According the second criterion, Ivory coast, Benin and Gabon, also countries connected to SAT3 were added as well as Niger, through which the planned trans-Sahara connection from Nigeria to Algeria will pass as well as a possible future connection from Senegal to Sudan.

Out of the remaining countries in the region (Mauritania, Gambia, Guinea, Sierra Leone, Liberia, Mali, Burkina Faso, Togo, Chad, Central African Republic, Equatorial Guinea), Burkina Faso and Mali were selected to illustrate the issues related to the necessity for transit to reach the intercontinental links, together with Chad and Central African Republic due to their strategic positions to connect a regional backbone for Western and Central Africa (WACREN) to Ubuntunet covering Eastern and Southern Africa.

Regional backbone (RREN)

A regional backbone will serve as a vehicle for academic peering, both regional and global, and Internet transit for NRENs in the region in the same way as NREN serves their member institutions. The feasibility of a regional backbone will be explored.

Country analyses

General data on each country has been collected from the CIA World Fact book 2008 edition, which is available at www.cia.gov/library/publications/the-world-factbook/

For each country the following parameters will be studied:

1. Stakeholders in research and education networking

Universities are key focal points for international cooperation and for the country/region to develop into a knowledge society. All sectors depend on universities to efficiently fulfil their roles in research, education and outreach. To be able to take on this responsibility efficiently, universities in the region need access to similar resources as its peers on other continents.

Universities also represents a mature, homogeneous and commercially neutral user group with strong backing, both internationally and nationally, and at the same time the most
important capacity building force.
The study explores how these facts are acknowledged in the different countries, in terms of commitments from the primary stakeholders and by taking research and tertiary level education into account in the National ICT policy and its implementation plans from the perspective of different sectors of society.
The possibility of a time limited feasibility phase should be explored in which the universities gets access to fibre to deploy their academic network in return for them providing pilots, education and training tailored to national needs. This is an approach that has served well in many other countries to create awareness and build capacity.

2. Policy and regulatory framework
The main questions to answer are:
− What rules apply for provision of access to fibre infrastructure and broadband services
− Can research and tertiary level organisations organize and get a license to build and operate a national non-commercial data network with transborder interconnections dedicated to research and tertiary level education, including all levels in the communication systems architecture: routing, data links, lease/deploy passive fibre.
− What understanding do policy makers and the regulator have regarding the special character of NRENs, how they fit in the future communications landscape from a regulatory point of view and how the NREN can actually serve the regulator as a show case in the relation to other operators and large consumer groups

Pointers to the policy-makers and national regulators in the telecommunication area in African countries can be accessed e.g. at www.africantelecomsnews.com/List_of_African_telecommunications_regulators.html

3. Existing and planned fibre infrastructure
What fibre infrastructure is available and under what conditions can an NREN get access to dark fibre

4. Maturity of the NREN formation process
As a starting point the following criteria are suggested:

1. NREN internal maturity, including formal organisation, availability of adequate human resources both on the NREN level and at member institutions, proof of required permissions/licenses from the national regulator, assigned numbers from AfriNIC (AS-number and IP-address spaces), quality of existing interconnections between NREN members, quality of member campus networks, number of connected clients, existence of an Acceptable Use Policy (AUP) complying to the AUP of GÉANT and interconnected global research and education networks, existence of an NREN network design and procurement documents for procurement of links (dark fibre, wavelength, link level capacity) and network elements (routers, switches, servers), relations to other NRENs and RRENs, and potential “lighthouse demonstrators” that can illustrate immediate impact of the RREN when deployed. Most of this information can covered in more detail by filling in a questionnaire provided by TERENA.

2. Openness of the national regulatory environment for building and operating a strictly non-commercial national network dedicated to a closed user group consisting of research and higher education institutions, including all levels in the communication systems architecture: network level (routing), link level, and physical level (lease/deploy passive optical fibre) and also including cross-border connections.

3. Availability of infrastructure facilitating RREN and NREN interconnections to its member institutions, in terms of leased lines, wavelengths or dark fibre from several infrastructure owners/operators capable and willing to participate in open and transparent procurements.

One source that we have been using to find institutions for research and higher education, potential NREN members, is www.university-directory.eu

5. Supply chain
In order to establish sustainable research and education networks, key elements of the supply chain needs to be available
- What telecommunications service providers are available for an NREN to buy wavelengths or data link services from and what conditions do they offer?
- What system manufacturers and distributors are available in the local environment?
- What human resources are available for management, systems and network administration of broadband networks and what capacity is missing?

**Information acquisition**
Information for this study has been collected via Internet, direct interviews on location and contributions from local experts in each country. The core team has visited Benin, Ghana, Nigeria and Senegal. Visits planned to other countries in the region have met various logistics problems.

**Recommendations**
On the national level, the recommendations are related to organisational issues and migration from VSAT-based networks to terrestrial networks based on leased link level capacity, wavelengths and/or dark fibre.

On the regional level, the recommendation includes organizational issues, possible routes for a regional network and its peering interconnections to the global academic infrastructure as well as transit connections to the Internet in general.
3. Regional backbone in West and Central Africa

There seems to be several possible solutions for the establishment of a regional backbone for West and Central Africa. The challenges involved are discussed in this section.

Maturity of the RREN process - WACREN

During 2009 the discussions about a regional backbone for research and tertiary level education in West and Central Africa (WACREN) has been intensified. There is however yet no incorporated RREN body. There seems to be little communication between the emerging NREN formation processes. In several cases we have found that the leaders of the processes in the different countries have never met or even heard about each other.

In order to facilitate external support and stimulate the national processes, we recommend that this process is started in parallel with the NREN processes by incorporating WACREN with an interim board including trusted representatives from the national processes and perhaps an external member as advisor, until a regular member council is in place. This work could be facilitated by using the documents and procedures set up by the Ubuntunet Alliance as templates and adapt them to fit the WACREN situation, including the first version of the Ubuntunet Alliance Strategic plan (the Zomba plan) and the by-laws used when incorporating Ubuntunet Alliance as a foundation. Even the selection of domicile of the organisation could be a long discussion before trust is established. To facilitate trust-building and not to reinvent wheels, dialogues should be opened with colleagues in the Ubuntunet Alliance, in North Africa (EUMEDNET members) and established NRENs on other continents.

Besides the incorporation of a formal body, the most urgent tasks include making a strategic plan including the network design outline necessary to file applications to get assigned numbers from AfriNIC (AS-number and provider independent IP-address space), business model and fund raising strategy. The need for licensing and other regulatory issues should be discussed both with WATRA and national regulators.

Stakeholders in regional research and education networking

Having entered the agreement with the European Commission regarding the 19 Lighthouse projects, the first of which concerns connecting research and education networks in Africa to GÉANT, the African Union commission is clearly a stakeholder on the policy level. This fact should be emphasized in the subregional and national level discussion about the importance of supporting the establishment of NRENs. Since ICT is a basic empowering factor for the knowledge society in general, this argument is valid for all sectors of society, but especially for the research and higher education sector that provides all sectors with human resources.

On a subregional policy level, ECOWAS (www.ecowas.int) and WATRA (www.watra.org), the West Africa Telecommunications Regulators Assembly, are stakeholders. WATRA was formally established in November 2002 on ratification and signing of the Constitution by the seven member states. The membership has since grown to 15. WATRA membership consists of the established independent National Regulatory Authorities (NRAs) and departments for the regulation of telecommunications services established by governments of member states in the ECOWAS sub-region and Mauritania. WATRA, recognising the poor state of telecommunications development in the West African sub-region and the critical role of telecommunications in the socio-economic development and growth of nations worldwide, reached a consensus to establish a forum, which will facilitate the harmonisation process towards an integrated telecommunications market in West Africa, provide an avenue to share experiences and information, proffer solutions to common problems and chart a way forward for the development and advancement of telecommunications in West Africa. The research and education networks should be interesting partners in this work representing a large and well organised consumer group on the communication market with high competence and advanced needs that will drive the market forward.

The producers on the communication market are also obvious stakeholders, including infrastructure owners, service providers, system manufacturers and other actors in the ICT supply chain.

On the consumer side, all research and tertiary level education institutions are stakeholder, but also other user groups will benefit from a more rapid uptake of new applications, services
and networking standards that African universities will contribute, like their peers on other continents have over the past decades.

**Existing and planned fibre infrastructure with regional and intercontinental coverage**

**General market conditions**

The price for broadband has largely been defined by the prices and conditions for VSAT connectivity also in these countries where SAT-3 are present and would be expected to have a major impact on the market. The VSAT costs also include a one off cost for a small disk and receiver for single company or more or less private use, not to feed a network of many users. Even in university campuses you can frequently find several VSATs not even connected to a common campus network. The price level for VSAT capacity has been reduced lately, in particular for users that have syndicated their buying, from the level of USD 5000/Mbps/month to 2500 to 3000. Even lower numbers has been reported but lately a shortage seems to have pushed the minimum levels up above 3000. A weak buyer probably pays twice that price or has other arrangements on contention ratio limiting his effective capacity.

A new and interesting factor in satellite capacity is the O3b proposal using low orbit satellites. Not only will this help redefine the bandwidth to megabit speed but also set a new price level, USD500/Mb/month for areas away from coastal capitals, the latter being the only areas with reasonable backbone alternatives to reach the landing sites of international submarine cables, existing or planned. It is important to note that the O3b approach uses a more expensive terminal than VSAT. This will no doubt link into discussions of using it to feed “broadband islands”, areas of many users like a town or small district connecting to the uplink site via various fibre or wireless MAN-type networks feeding the access network locally. Ultimately, this will drive the market development to gradually link aggregated and developed demand into terrestrial fibre rings hooking into the national backbones with international connections. The difference between pundits may just be how fast this transition will take place, in more densely populated areas and, in particular, in urban areas.

A key problem for any submarine cable system is the lack of network facilities between the landing site and the end users. The rapid roll-out of mobile phone systems created a footprint now mature to be turned into more. All major GSM-operators are now considering capacity and systems upgrades to also conquer the broadband market, not least following the success of broadband wireless of 3G operators elsewhere, but also realizing that their transmission capacities between sites now have reached a level where they need fibre, not microwave links. Then they may as well consider extending that fibre, or use a microwave link, to service a single big user, like a bank or a university campus. The measure will be how many active PCs you find to service on any one site. The first casualties will be the “one to two PC sites” fed by a 128kb VSAT. All of these will be fading away rapidly as 3G/LTE shows up. Those users could be looked upon to be the low hanging fruit. In that category you also find all the departmental VSATs found in universities. A weak campus network activity will no doubt mean that the transition will be to several 3G fed WiFi-LANs or even a rapid uptake of individual user 3G cards for Internet access. It is in this environment the NREN and campus network activities will be framed. What will be between the campus users and the landing of the submarine cable? No doubt will even the weakest national backbone activity reach most of the university towns in a fairly short time. Also, the GSM/3G operators are already there with a pretty heavy user base.

The **combined** per Mbps cost for the international portion over the submarine cable and the national backbone must then stay under the USD 500 mark in order to be competitive with the O3b indication.

Ultimately, universities will no doubt get their campus networks sorted out and get a fixed fibre broadband connection to it. Then the NRENs will have to build the trust among its members to become their dedicated upstream network provider with their own assigned numbers (IP-address space and AS number) rather than a 3G-operator turning into a broadband provider with managed ip-services that cannot offer academic peering. The organizational and trust status of the NREN will be the answer to this. It will not be as much a question about potential cost savings as perceived risks, organizational independence and outright envy.
External support will be there to support both initial CAPEX and capacity building to create mirror images of NRENs elsewhere in the world.

National backbones has been a topic for much discussion and little action until reasonably priced submarine cable capacity seems to be visible. Cash deprived old PTTs have stayed on a strategy of milking whatever they can get out of a “low volume – high price” market as they had little incentive to lower the price just to run out of both access capacity and the small but crucial revenues they enjoyed on an overpriced monopoly gateway. There needs to be a different attitude as well as capability by the incumbent operators to change this. But first there need to be an understanding on policy level of the realities of the contemporary telecoms market.

There is no way to combine the old, inefficient, overstaffed, poorly managed and protected monopolies with the ICT society needed tomorrow. The way the various submarine cable systems will be utilized in different countries will be a reflection of this.

**Submarine cable systems**

**ATLANTIS-II**
This cable connects Portugal, Canary Islands, Cap Verde, Senegal, Brazil and Argentina. It is in operation since 2000 and has currently a capacity of 19,840 Mbps.

**SAT-3/WASC**
The capacity of SAT-3 ([http://safe-sat3.co.za/](http://safe-sat3.co.za/)) is currently 120Gbps its designed max capacity. It is likely to be upgraded to what new transmission technology can provide, 320 Gbps, by 2010.

The unused capacity is marginal and is expected to be filled rapidly if the price is reduced. However, some information suggests that the club consortia members have enjoyed an uneven growth and have had different needs and desires for upgrades over the early years of the cable.

From a West African point of view it is important to realise that a big part of the SAT-3 is “an express way with no exits” from South Africa to Europe. Prior to the last upgrade it was only four times 2.5 Gb/s, one fifth of the total capacity, that was diverted to connect all other landings. It is unclear from documents made public if the upgrade to what was initially said to be the design ceiling, 120 Gb/s, changed this proportion.

The major capacity in the upgrades seems to have been directed towards a global transit need Europe –Asia. General vendor information suggests that a future upgrade of terminal equipment could still be done pushing the total system capacity upwards yet another notch before the wet plant of SAT-3 with its 200 regenerators and branching units would not cope any longer. This is of cause of importance for any potential competitor, as any further upgrade would not only pay for itself within a very short time, the first upgrade had a USD 30 million price tag, but as this will pave the way for SAT-3 owners to effectively compete at a fraction of the cost base until the next 100Gb/s or so is sold out too. It is perhaps not surprising that issues of redundancy and political and commercial risk are floated often in relation to additional cable projects.

This also suggests where the driving demand for a complete route from Europe to South Africa and beyond: Restoration of East Africa traffic on EASSy, and not least the one year ahead SEACOM, will be important but perhaps the SEACOM capacity to India may need an alternative route to passing Egypt. Available capacity may in any case only be partly attributed to considerations regarding traffic in West African markets. Nevertheless, there are projects considering cables not even reaching Angola, suggesting that some players regard additional regional demand justifying a new build: Glo-1. Main-One and FT dominated WASC.

Several proponents have over the years suggested that the prices on the SAT-3 have been kept at an unreasonably high level, USD 8000-15000/Mb/month. An argument has often been that operators would sell so much more if they lower the price that it would make sense. This view often compares with the European legacy and its price elasticity on broadband, mainly carried over ADSL. It is, however, easy to forget the lack of wireline infrastructure in Africa. There is simply no backbone and no access network to carry a growth of the necessary magnitude. At least not until lately. It is possible to note a rapid rollout of national fibre cables, a strategy change of the mobile phone operators towards being vertically integrated full service
operators, privatisation and acquisition by players like FT of the PTT, and a recent strategy for growing volume on international traffic on SAT-3 by lowering the price.

Indicated wholesale prices, in USD /Mb/month, based upon SAT-3 connectivity to the national landing and with connectivity to Europe have lately been indicated to be in

- Senegal 1300
- The Ivory Coast 1600
- Ghana 2000,
- Cameroon between 7000 to 8000 and
- Gabon 10000 to 15000.

Levels in Nigeria and Benin should first be equalising as there is now a cross border flow of traffic to Benin from Nigeria partly terminating at the SAT-3 landing in Cotonou. More than one Nigerian operator is concerned with having its traffic through the NITEL controlled landing, not for cost reasons only. Prices could be expected to be approaching the Ghana levels shortly. However, the latency numbers suggest that at least some of the traffic from all landing points south of Accra is routed through South Africa. Besides being a little bit odd given the major traffic flow to be focused on other destinations, it raises some questions on the efficiency of the configuration.

After the south African opening of access to the SAT-3 landing, enabling also Neotel to gain access directly to SAT-3 at the landing on April 10th 2008, not being forced to use Telkom, prices has been reduced on the South Africa – UK route to below 2000 in big volume and about 2500 in retail. Obviously Neotel is taking advantage of capacity on SAT-3 belonging to one of its owners VSNL who has a stake of the capacity but have not had the possibility to connect any traffic until now in SA.

Comparing this with numbers from mid 2006 shows South Africa prices to have more than halved from the USD 5000 level. This is also true for Cameroon that then had prices around USD 15000. A level frequently found with all SAT-3 operators pre 2005.

It is instructive to see the correlation of market openness, growth, investments and price reductions. Obviously, the international operators like FT, MTN and Zain do have a regional approach. This will no doubt drive complementary cross border links to the national backbone fibres many already installed or to be rolled out shortly.

The current pricing level can also be illustrated by recent renegotiations of VSAT agreements of the Bandwidth Consortium (www.foundation-partnership.org). SAT-3 capacity has been offered at 1.8 USD/kbps/month while the previous VSAT agreement at 2.33 USD/kbps/month has increased to 3.2 USD/kbps/month.

According to the shareholder agreement (www.cipaco.org/spip.php?article922) , the largest investors in the SAT-3 cable are: France Telecom (12.08%); Nitel (8.39%); and TCI, a subsidiary of AT&T (12.42%) and VSNL (8.93%). The total investment for both the SAT3 and SAFE portions of the cable was US$595 million.

Additional submarine cable projects

Globacom Glo-1 submarine cable
Glo-1, www.mnodirectory.com/AMETW/2007/issues/259mar07.htm is expected to start operating during 2009. The plan is to connect Nigeria and the UK with landing stations in Spain, Portugal, Morocco, Senegal, Mauritania, Sierra Leone, Liberia, Togo, Cape Verde, Gambia, Guinea Bisau, Guinea, Cote d'Ivoire, Ghana, Benin and Nigeria. The cable can manage up to 32 channels with each channel capable of supporting bandwidths up to 10 Gbps or STM 64.

Some media claim that since the Nigerian share of SAT-3 is two lit STM 1 (310 Mbps), the Glo-1 adding a factor 1000. However, other sources claim that the main SAT-3 cable station, completed in December 2001, started handling traffic in April 2003 (15 months later) with 13 STM-1s (155 Mbps) available (3 in reserve). 78% of one STM-1 frame in use (connected to sole domestic fiber) by Shell Nigeria in Dec 2003.

The Globacom project seems to have made a halt half way on its way from Europe and is by some analysts ( www.terabitconsulting.com ) considered to be in “wet storage”. If this was related to lack of landing rights in one or more of the intended countries, commercial concerns of Globacom on building an access position first, financial constrains, or just
missing the Alcatel installation window, is unclear. Considering the heavy demand for the existing laying ships a RFS date first half of 2009 seems unlikely.

**Infinity**
In a first phase to be operational in the end of 2010 but still at a planning stage, Infinity (http://allafrica.com/stories/200803311854.html) will have landing points in Portugal, Senegal, Ghana, Nigeria, Cameroon, Angola and South Africa.

Additional landing points to be added in phase 2 include Canary Islands, Mauritania, Gambia, Guinea-Bissau, Guinea, Sierra Leone, Liberia, Côte d’Ivoire, Togo, Benin, Equatorial Guinea, Sao Tome, Gabon, Congo, DRC, and Namibia.

Inland routes will be explored to Mali, Burkina Faso and Niger.

Ownership and commitment to implementation is still heavily debated.

**Main Street Technology One**
This cable (www.mainonecable.com) will start in Portugal, interconnected with cables to London, New York and key cities in Asia.

In phase one, scheduled to be operational 2010, it will have landing stations in Accra and Lagos and If successfully licensed, also in Morocco, Senegal, Cote D’Ivoire, Nigeria, Gabon, Congo, Angola and South Africa.

Once commissioned in 2010, Main OnE will provide the much-needed bandwidth on the continent. The Main OnE cable system will have a design capacity of 1.28 Tbps.

Commitment, financing and supply contracts are not clear at this point.

**African Cable to Europe (ACE)**
This initiative taken by Etisalat, the France Telecom group and Maroc Telecom that have invited other telecommunication operators along the African west coast to join. The ACE cable is meant to complement SAT-3 by connecting to connect countries that are not connected to SAT-3. Landing points are being discussed in France, Spain, Portugal, Morocco, Mauritania, Cape Verde, Gambia, Senegal, Guinea-Bissau, Guinea, Sierra Leone, Liberia, Ivory Coast, Ghana, Togo, Benin, Nigeria, Cameroon, Equatorial Guinea, Gabon. The cable is planned to become operational 2011. The plans include two fibre pairs, initially 4*10 Gbps, maximum capacity 1.28 Tbps.

The structure suggest it to be designed also with redundancy with SAT-3 in mind.

The MoU process between the intended participants is close to be finalised. With the heavy FT commitment it is unlikely that there will be any major delays. It is more or less entirely an in-house cable project for FT, its subsidiaries and close partners. Planning presentations suggests it to be closely related to subsidiary backbone and access investments in several West African countries, also landlocked. It makes further FT interest in acquiring remaining privatisation objects even more likely, providing a strong FT presence under the brand name Orange in all West Africa.

It is unclear if FT or any of the partners will sell any submarine cable capacity wholesale, or just offer capacity nationally on a retail basis.

**West African Cable System (WACS)**
An agreement has been signed by NEPAD, Vodacom, Telkom, MTN, Broadband Infraco and Neotel to build a West Coast cable to stretch from Cape Town to the UK and connect to the NEPAD Uhurunet project. It is planned to be implemented 2010-2012 with a capacity of 3.8Tb. Details and conditions are unclear.

**Terrestrial cable systems**

**Trans-Saharan Highway**
This project (http://en.wikipedia.org/wiki/Trans-Sahara_Highway) started in 1963. This road project has recently been accelerated and is expected to finish 2010-2011. The plans include a highway, a pipeline and a fibre optic cable system from Algiers to Lagos via Agadez in Niger (Route 2 on the map in appendix).

**Trans-Sahelian Highway**
The trans-Sahelian highway is stretching from Dakar in Senegal, via Bamako in Mali, Ouagadougou in Burkina Faso, Niamey in Niger, Kano in Nigeria, Ndjama in Chad (Route 5 on map in appendix) and further from Ndjama to Kosti in Sudan and via Ethiopia to
Djibouti (Route 6 on map in appendix). There is fibre already from the Red Sea to the Chad border as well as from Dakar to Ouagadouguo and soon onwards to Niamem. There are, however, missing pieces through Chad and Niger with unknown time plans. All these projects are controlled by the respective incumbent carrier.

**WAGPCO**

There is some discussion about deployment of optical fibre along the pipelines of the West African Gas Pipeline Company (www.wagpco.com). There seems however currently not to exist firm plans for such deployments. The WAGPCO pipeline system is partly terrestrial and partly submarine.

**Suburban Telecom**

Suburban Telecom (www.suburbantelecom.com) is based in Abuja, Nigeria but has a regional focus. It has an extensive backbone fibre network in Nigeria, currently about 1000 km, and is planning deployment of another 1000 km during 2009. The company also has established a regional network (WA-Net) with connectivity extending into Europe and South Africa via SAT-3, including own cross-border links Nigeria-Benin and access to other regional in-land fibre routes via swap-deals connecting it to the capitals of Mauritania, Senegal, Gambia, Guinea-Bissau, Guinea, Mali, Burkina Faso, Ivory Coast, Ghana, Togo, Benin and Niger.

**ZTE**

China's largest listed telecoms manufacturer, Shenzhen-based and state-owned ZTE (www.zte.com.cn/) is established in several African countries including Congo, Kenya, Libya, Niger and Sudan. It is exporting networking products, establishing joint ventures and investing in local communication operations.

**Other**

MTN, Zain, Vodafone and other major multinational mobile phone operators are now all embarking on a route to create new expansion out of the footprint and resources they have. What was an almost total focus on narrowband mobile voice has now changed.

Not only is this a result of a saturating market with increasingly thinner and more difficult markets remaining: Low density rural areas with people with low purchasing power. It is also due to a regulatory change away from very narrow and restrictive licenses towards more open and broad licenses. In short, operators are now doing what they were forbidden to do just a few years ago. The typical high market share mobile phone operator is now enjoying a pretty dense network covering the major population centres and the roads connecting them. The first thing is to replace heavily loaded microwave links along these routes, also with future cross border links in mind. In many cases this will also increase the reliability of the traffic as several routes are suffering from weather depending disruptions in heavy rains with massive increase of attenuation affecting a major part of the traffic.

We have now come to a point where this enables the added business concept of wireless broadband provisioning in a market just about to be ready for a broadband expansion, albeit from a low scale.

As for infrastructure, all of these operators are in various ways into a whole array of buy, build and swap activities. Their core need is to have fibre strands and turn that asset into high capacity access and backbone structures, not to necessary own all cables themselves. In that sense, they are a part of the horizontal layering now visible also in West Africa. Other companies, like Suburban and power utilities, more clearly take the role of being a carriers carrier. These companies will be key for any NREN desire to lit dark fibre on their own. Even negotiating lambdas out of some of the access and services focused operators network may pose a problem for a considerable time. Since many NRENs may not need more than a STM-4 for a considerable time, there will still be a reason to consider deals with the broadband business units of the mobile phone companies. There is no readiness or any pricing formulas available currently. The operators still see universities as fragmented down to units ripe for substituting VSATs with 3G broadband on a user per user basis.
4. Country analyses in West Africa (ECOWAS members and Mauritania)

Ecowas. Mauritania is a member of the African League

4.1 Mauritania

Population ~ 3,364,940 (2008), arabic, left ECOWAS 2001

Policy and regulatory framework
Policy is managed by the government (www.mauritania.mr) and Regulation is managed by Autorite de Regulation (www.are.mr)

Existing and planned fibre infrastructure
There seems to be little optical fibre in Mauritania. Besides the OPGW fibre deployed in the Regional High Power Development program to Senegal and Mali (Manantali), there is some locally in Nouakchott, mainly connections between the different telecom operators.

NREN Maturity
University of Nouakchott (www.univ-nkc.mr) which seems to have a functioning campus network connected to the Internet. There is no response to request for information regarding NREN activities.

Communication service providers
Mauritel (www.mauritel.mr), the national telecommunications company, was privatized in 2001 but remains the monopoly provider of fixed-line services; fixed-line teledensity 1 per 100 persons; mobile-cellular network coverage extends mainly to urban areas with a teledensity approaching 35 per 100 persons; mostly cable and open-wire lines; a domestic satellite telecommunications system links Nouakchott with regional capitals.

Mauritel Mobile is a subsidiary of Mauritel providing mobile services.

Mattel (www.mattel.mr) was the first GSM operator in Mauritania created a company created on 2000-05-11 by a Tunisian - Mauritanian Partnership.

Chinguitel (www.chinguitel.mr) provides fixed, mobile telephone services as well as Internet access and VPN services.

4.2 Cape Verde

Population ~ 427,000 (2008), lusophone, one of the 15 ECOWAS members

Stakeholders in research and education networking
Besides the policy makers and regulators in the research and higher education area and in the communication area, the research and higher education institutions, as well as other users of communication infrastructure, and ICT industry, including Cape Verde Telecom (CVT)

Policy and regulatory framework
The policy maker in the ICT area in Cabo Verde is the Minister of Communications and the independent regulator is Direccao Geral das Communicoes (cv.acreg.org), a member of WATRA. The NICI plan is available at www.uneca.org/aisi/nici/Cape_Verde/cape.htm. According to WATRA, an NREN organisation would probably not need a license for the establishment and operation of a dedicated non-commercial network serving only research and higher education institutions, as long as they use infrastructure (digital links, optical wavelengths or dark fibre) belonging to licensed operators. We have however, not yet been able to confirm this with the national regulator in Cabo Verde.

Existing and planned fibre infrastructure
There is a fibre-optic ring, completed in 2001, that links all islands and a landing point for the Atlantis-2 fiber-optic transatlantic telephone cable that provides links to South America, Senegal, and Europe; HF radio-telephone to Senegal and Guinea-Bissau; satellite earth station - 1 Intelsat (Atlantic Ocean) (2007)
NREN Maturity
There are two universities in Cape Verde, but no NREN process in progress,
- Jean Piaget University of Cape Verde (www.unipiaget.cv)
- The University of Cape Verde (www.unicv.edu.cv) was formed in 2006-2007 by the merging of colleges operating in different locations:
  * ISE (Instituto Superior de Educação) located in Praia
  * ISECMAR (Instituto Superior de Engenharias e Ciências do Mar) located in Mindelo
  * INIDA (Instituto Nacional de Investigação e Desenvolvimento Agrário) located in São Jorge dos Órgãos

Communication service providers
The major service provider is Cabo Verde Telecom (CVT) providing Internet access and ISDN services; cellular service introduced in 1998; broadband services launched in 2004.

4.3 Senegal
Population ~ 12,853,259 (2008), francophone, one of the 15 ECOWAS members

Policy and regulatory framework
Policy and regulation in the area of higher education is managed by the Ministry of Education (www.education.gouv.sn) and the Direction de l’Enseignement Supérieur (DES).
Policy and regulation of the communications market is managed by the Ministry and the independent regulator, Agence de Régulation de Télécommunications et des Postes (ARTP)
The regulatory framework is not adapted to facilitate the development of the information and knowledge society by a very competitive market. The market is still a high price-low volume one and there is limited competition for supply of Internet and telecommunication services.
On the policy level, there is an agreement made between DES and ARTP to support for higher education and research.

Existing and planned fibre infrastructure
There is about 3000 km optic fibre in operation, mainly owned by SONATEL. The government has deployed own fibre cables for its own use managed by Agence De l’Informatique de l’Etat <www.adie.sn> (see figure below). This infrastructure will also be available for the NREN.
Communication service providers
The privatized incumbent SONATEL is operating a digital telephone network as well as a national IP network with 3.5 Gb/s internet bandwidth. The monopoly grace period regarding international traffic granted to Sonatel in the privatization, initially expiring only 2012, is subject to renegotiation.

Wireless services of France Telecom's GETESA (Equatorial Guinea), SONATEL (Senegal), and Ikatel (Mali) have been rebranded under the brand name Orange.

An Internet exchange point (IXP Senegal) was established in July 2006 with support from the Catia project.

NREN Maturity
During a two day meeting at UCAD (University of Cheikh Anta Diop of Dakar) in May 2008, rectors of higher education institutions discussed the formal creation of an NREN in Senegal. The meeting identified the challenges involved, including the high cost/low volume situation due to the fact that policies and regulations in the communication sector is not yet adapted to facilitate the development of information society leading to limited competition for supply of Internet and telecommunication services. The high costs lead to weak use of the ICT in the Education system.

As already mentioned, there is a policy agreement made between the Direction de l’Enseignement Supérieur (DES) and Agence de Régulation des Télécommunications et des Postes (ARTP) to support for education and research.

A consortium of Higher Education institutions, public and private, has been formed under the Centre Informatique pour l’Enseignement et la Recherche (CIFER). The mission of the consortium is to establish an NREN in Senegal, promote ICT access for higher Education, support the development and sharing of on-line information resources, e-learning materials, etc., and sharing experiences and best practices to support education and training of campus network staff. A sustainable business model is under discussion.

In the consortium, there are the five public universities University of Dakar (UCAD), University Gaston Berger de St Louis (UGB), University of Thies (UT), University of Bamby-CUR (UB) and CUR de Ziguinchor (CURZ). There are also 64 private universities.

In July 2009, a meeting is called to kickoff the Senegalese NREN SENRER with participation from the five public Research and higher institutions, Agence De l'Informatique de l'Etat <www.adie.sn> and the regulator ARTP.

The initial members will be the five public universities, which will get access to the government fibre infrastructure managed by ADIE.

- Université Gaston Berger is already connected.
- Université de Thies and Université de Bamby will be connected during July
- Université Cheikh Diop (UCAID) will be connected by October 2009
- Université de Ziguincher south of the Gambia will have to wait for the start of operations of the Glo-1 submarine cable expected to have landing points both in Dakar and south of the Gambia

4.4 Gambia
Population ~ 1,735,464 (2008), anglophone, one of the 15 ECOWAS members

Policy and regulatory framework
The Gambia Public Utilities Regulatory Authority Act, 2001 provides for the establishment of PURA (www.pura.gm)), a multi-sector regulatory authority, to regulate the activities of providers of certain public utilities amongst them energy services (electricity, petroleum and gas), communications services (telecommunications, broadcasting and postal services), water and sewerage services and transport services (on land, water and in the air).

Existing and planned fibre infrastructure
There is a fibre cable connecting The Gambia to Senegal. It is currently unclear how to get access to it. A packet switched data network is available. There is microwave radio relay links to Senegal and Guinea-Bissau and there is one satellite earth station (- 1 Intelsat, Atlantic
NREN Maturity
There is one university. University of The Gambia (www.unigambia.gm), but no response regarding emerging NREN activities.

Communication service providers
There are four service providers in the communication sector; GAMTEL (fixed line), GAMCEL, AFRICELL and COMIUM (GSM). Another GSM service provider, Q-Cell, bringing the total communication service providers to five will become operational in early 2009. The combined fixed-line and mobile-cellular teledensity approaching 30 telephones per 100 persons
There are several Internet Service providers, including Ganet (http://qanet.gm/)

4.5 Guinea-Bissau
Population ~ 1,503,182 (2008) lusophone, one of the 15 ECOWAS members

Policy and regulatory framework
Policy is set by the Ministry of Telecommunications. The regulator is Instituto das Comunicações da Guiné-Bissau (www.icgb.org)

Existing and planned fibre infrastructure
Combination of microwave radio relay, open-wire lines, radiotelephone, and cellular communications; fixed-line teledensity less than 1 per 100 persons; mobile-cellular teledensity reached 7 per 100 in 2005. Guinea-Bissau has a landing-point of the planned ACE cable due 2010-2011, if this cable is deployed.

NREN Maturity
There are several universities, including Universidade Amilcar Cabral (www.grupolusofona.pt/portal/page?_pageid=394,1&_dad=portal&_schema=PORTAL)
There is, however, no response to our request for information about NREN activities.

4.6 Guinea
Population ~ 9,806,509 (2008), francophone, one of the 15 ECOWAS members

Policy and regulatory framework
Policy is set by Ministére des Postes et Télécommunications. The regulator is ACREG (www.gn.acreg.org)

Existing and planned fibre infrastructure
Guinea has a landing-point of the planned ACE cable due 2010-2011, if this cable is deployed.

NREN Maturity
A list of universities in Guinea is maintained at www.university-directory.eu/Guinea/Guinea.html
There is no response to our request for information about NREN activities.

4.7 Sierra Leone
Population ~ 6,294,774, anglophone, one of the 15 ECOWAS members.
There is no response to our request for information about NREN activities.

4.8 Liberia
Population ~ 3,334,587 (2008), anglophone, one of the 15 ECOWAS members.
In spite of several requests for information about emerging NREN activities to University of Liberia in Monrovia, there has been no response.
4.9 Mali
Population ~ 12,324,029 (2008), francophone, one of the 15 ECOWAS members

Policy and regulatory framework
Both policy and regulation is managed by Ministere de la Communication et des TIC (http://mali-reforme-telecom.mctmtl.com/).

Existing and planned fibre infrastructure
There are optic fibre cables from Bamako connected to SAT-3 via Dakar, Abidjan and Togo - Cotonou. Both Orange/Ikatel and SOTELMA/Malitel have installed an optical fibre cable between Bamako and Kayes. Malitel deployed their fibre in the power line between the cities.

The Regional Hydro-power Development program (RHDP) has had an unintended positive impact on the telecommunications sectors of the OMVS member states (Mali, Mauritania, Senegal) providing them with the opportunity to design a sub-regional telecommunications project via the telecommunications equipment installed for SCADA purposes based on the dual-purpose optical fibre cable linking Manantali to all the high-voltage substations and the national grids of the three countries, for which SOGEM has already signed an operational agreement with the telecommunications companies. This project provides a digital, interconnected telecommunications system for Mali, Senegal, and Mauritania, which can be expanded to other neighbouring countries.

NREN Maturity
The main research and higher education institution is Université de Mali. In spite of several requests for information about emerging NREN activities there has so far been no response.

Communication service providers
The competition between the mobile telephone companies Malitel, a subsidiary of the incumbent operator Sotelma, and Orange (formerly Ikatel), a subsidiary of France Telecom, has resulted in a substantial reduction in prices of all communication services over the last few years.

SOTELMA, the incumbent telecommunications operator in Mali, Société des Télécommunications du Mali (www.sotelma.ml) is about to be privatized. Services include both fixed line connections, including ADSL, and, via the subsidiary Malitel, wireless (terrestrial and VSAT) connections, no dial –up connections, government telecommunication services, including the university although the university network has a lot of problems. To connect to SAT-3, SOTELMA seems to be using optical fibre through Togo-Benin and Cote d’Ivoire.

Orange Mali (www.orangemali.com), formerly known as Ikatel, is a private company owned by France Telecom, uses optic fibre, wireless (SAT-3) and is present in many districts in Mali. They are considered as leaders in Telecommunications in Mali. They have a good connection and qualified personal. They have also dial up connection.

Afrifone, It is the second largest provider of services based on a terrestrial wireless network www.afrifone.com.

Datatech, Burotic, Spider, and Experco are small providers.

4.10 Burkina Faso
Population ~ 15,264,735 (2008), francophone, one of the 15 ECOWAS members

Policy and regulatory framework
The regulator in the telecommunications sector is ARTEL, www.artel.bf

Existing and planned fibre infrastructure
Fibre cables exist between
- Ouagadougou and Bobo Dioulasso,
- Bobo Dioulasso - Sikasso - Bougouni - Bamako - Dakar,
Bobo Dioulasso - Banfora - Korhogo - Bouaké - Yamassoukoro - Abidjan

NREN Maturity
Burkina Faso has two university centres, one in Ouagadougou and the other in Bobo-Dioulasso (the two main cities, about 400 kilometres apart), in addition to the College of Koudougou (approximately equidistant from Ouagadougou and Bobo-Dioulasso). The National Scientific and Technological Research Centre (CNRST) centralises the country's research activities. Université de Ouagadougou (UO) www.univ-ouaga.bf, Université Politeqnic de Bobo Dioulasso (UBP), Centre National de Recherche Scientific (CNRST). There is currently Sida support in the ICT area (www.dsv.su.se/research/sida/burkina.shtml)
The progress in this project is behind schedule and the formation of an NREN seems not to be imminent.

Communication service provider
The incumbent operator is Onatel (www.onatel.bf)
In Dec 2003 Alcatel announced the signing of contracts with ONATEL to modernize the transmission network and interconnect Burkina Faso with the neighbouring countries (Ivory Coast, Mali, Togo and Ghana) as well as getting access to the high capacity submarine cable SAT3. To be completed in 2004 Under the terms of these contracts, Alcatel supplied its SDH optical multi-service transmission equipment for the build out of a 1100 km transmission backbone. Alcatel also supplied the optical fibre cable in the eastern side of the country. The new transport infrastructure, is supervised by Alcatel's network management solutions (OMSN 1660 SM and TNM 1353 SH) and build a 420 km Fibre Optic Cable back-bone increasing the national network's traffic handling capability and allow interconnection of the network, initially to four other African countries.

4.11 Cote d'Ivoire
Population ~ 20,179,602, francophone, one of the 15 ECOWAS members

Policy and regulatory framework
Regulator: www.atci.ci

Existing and planned fibre infrastructure
SAT-3 has a landing point in Abidjan. There is terrestrial fibre along the routes from Yamoussoukro to Abidjan – San Pedro, Man – Toubá and Bouaké - Korhogo - Ferkessédougou- Ouagadougou. All campuses of the potential NREN members are located in Abidjan, Yamoussoukro and Bouaké reached by the fibre backbone connecting to SAT-3.

NREN Maturity
The following research and higher education institutions are potential members of an NREN in Côte d'Ivoire: CFTIC-INPHB, ENSEA, IPNETP, EST-LOKO, Agitel Formation, Abobo Adjame University, Bouaké University, Cocody University. There is yet no formal NREN formation process.

Communication service provider
An Internet exchange point was established in April 2006 with support from the Catia project.
4.12 Ghana

Population: ~ 23,382,848, anglophone, one of the 15 ECOWAS members

Ghana has a National ICT Policy and a related Plan for Accelerated Development – ICT4AD (www.ict.gov.gh) as well as an active consultative process involving all sectors of society, including the universities. The policy clearly identifies universities as one of the primary agents for implementation.

Notably, however, the policy concludes that the universities need to be strengthened and provided incentives and means to perform this task but does not mention how this should be accomplished and does not identify the need for a NREN. We have found little evidence of political commitment on the necessary level to get adequate resources allocated similar to the support of KENET in Kenya, Rwednet in Rwanda, MoRENet in Mozambique, etc.

Besides the necessary plans for incorporation of the Ghana NREN, GARNET (www.garnet.edu.gh), the process would probably benefit from a strategic document illustrating how GARNET can contribute to the socio-economic development laid out in the national ICT policy documents.

Stakeholders in research and education networking in Ghana

Key Public sector stakeholders

The selection of stakeholders discussed here include basic actors, key to the development of a knowledge based information society in all countries. The policy makers and regulatory bodies include both the communications sector and the power sector, since there might be reasons for cross-subsidies to stimulate development. Policy-making in the telecommunication sector is the responsibility if the Ministry of Communication (www.moc.gov.gh) and in the energy sector the Ministry of Energy (www.energymin.gov.gh). Policies in the area of Tertiary level education is managed by the Ministry of Education, Science and Sports (www.edughana.net) under which there is a National Council for Tertiary level Education (NCTE) that is regarded as a potential host for the GARNET board and management group. The ministry seems very active regarding ICT issues, including eLearning as illustrated by the patronage of the eLearning Africa conference held in Accra in 2008 (www.elearning-africa.com) and partnership with GeSCI in the Ghana eSchools project. The Netherlands is supporting a capacity building programme for supervisory bodies of tertiary level education in Ghana [Groningen].

The Ministry of Health (www.moh-ghana.org) is responsible for policy formulation, monitoring and evaluation, resource mobilization and regulation of the health services delivery, which is also affecting tertiary level education in the area of medicine. The responsibility of the direct provision of public health services delivery, including promotive, preventive, curative and rehabilitative care, is with the Ghana Health Service (GHS) and Teaching Hospitals. GHS seems to have an ICT policy intended to support health delivery.

Ghana is administratively divided in ten administrative regions that are again subdivided into 138 distinctive metropolitan, municipal and district assemblies. Ministry of Local Government, Rural Development and Environment is the supervisory body of all the district assemblies and their Chief Executives. Information on ICT policies, implementations plans and the current status of ICT usage on the district level can be found via www.ghanadistricts.com, a website developed and maintained in a public-private partnership including the Ministry with the objective to independently examine how the local governments tackle important socio-economic challenges.

A successful development of ICT usage in rural areas requires attractive offerings for local entrepreneurs both on the producer and the consumer sides. On the producer side the value chains involving distribution, sales, installation, repair and maintenance of equipment, such as network elements, computers, software products, etc. On the consumer side, there is a need for localization of all sorts of applications, especially those having a socio-economic impact, such as agribusiness, housing, transport, education, environment, employment, etc. Both sides need access to financial services, including banking, micro-financing, etc.
Key Private sector stakeholders

The key stakeholders on the private producer side include infrastructure owners and operators of all sorts as well as all sorts of actors in the value chains involving manufacturing, distribution, sales, installation, repair and maintenance of equipment. On the private consumer side, there is a wide spectrum from large corporations and Small and Medium-sized enterprises (SME) to local entrepreneurs. Information is made available by the Research ICT Africa! (RIA!) network about SME e-Access and ICT Usage in 14 African Countries, including Ghana. SMEs and local entrepreneurs may have less direct economic impact but are key to the longer term socio-economic development. Ghana Living Standards Survey (GLSS) provides information about level and trends in ICT penetration and usage.

Policy and regulatory framework

With two national operators, a third regional operator and four mobile networks, the annual growth of Ghana’s telecommunication markets has been impressive, especially in the mobile sector where the number of lines exceeds fixed lines by around 10:1. A total teledensity of little more than 15% and an Internet user penetration of less than 2% indicate a large remaining growth potential. The regulator on the telecommunications side is the National Communication Agency (www.nca.org.gh), on the energy side the Energy Commission of Ghana (www.energycom.gov.gh) and on the research and higher education side it is the National Council for Tertiary Education (NCTE – www.ncteghana.org).

Existing and planned fibre infrastructure

Publicly owned fibre infrastructure in Ghana

Most of the existing fibre infrastructure in Ghana, especially the backbone, originates from the power sector intended for management of the power distribution network (SCADA). The fibre was deployed by Voltacom, the power generating subsidiary of the Volta Regional Authority (VRA). The fibre is deployed in the ground wire of the high voltage distribution network (OPGW). The OPGW cables (from www.prysmian.com) include 12 fibre pairs (24 strands) of which one pair is used for SCADA purposes.

NCBC fibre cables available in 2008 (Source: NCBC)
Some fibre cables, mainly for local access networks, have been deployed by the incumbent, Ghana Telecom (GT).

Ownership of all fibre owned by the Government of Ghana has recently been transferred to a separate company, the National Communication Backbone Company (NCBC), that is extending the fibre infrastructure to a national backbone with support from the Government of China.

In July 2008, the Government of Ghana sold 70% of Ghana Telecom, including NCBC, to Vodafone. Part of the agreement is that NCBC fibre assets will be made available as an open shared infrastructure on non-discriminatory conditions. The business plan is expected to become public shortly.

**Privately owned fibre infrastructure in Ghana**

A consortium of Mobile operators, have deployed a fibre ring in Accra.

MTN, the largest of the six licensed cellular phone operators, has deployed fibre of its own. Most likely this is also to some extent the case with the other mobile phone operators, including Vodafone, Zain.

**Maturity of the NREN formation process - GARNET**

NREN activities in Ghana can be dated back to 1995 when The Balme Library, University of Ghana was designated as the National Node for the Fidonet email systems.

In early 1996 the Ghana National Committee on Internet Connectivity (GNCIC) was formed to promote the development of telematics in Ghana.

In 1997, an IFLA/DANIDA Project was established to link five university libraries, INSTI and counterpart libraries in Denmark to facilitate the document delivery. Different transmission technologies were used for this purpose, including telephone lines and wireless
connections, initially HF and VHF and later WLAN.

In 2001 the network was further strengthened through the provision of a high bandwidth link through the VRA Integrated fiber backbone connecting hubs at KNUST, UCC and UG. The network was named GARNET and had a board with membership from the four public universities, Centre for Scientific & Industrial Research (CSIR), and GNCIC. A technical team from Denmark Technical University provided support. This phase of GARNET was, however, short-lived (2001-2004). It was beset with problems of ownership and lack of cooperation at both organizational and technical levels, mainly due to poor infrastructure on the campus level, inadequate bandwidth etc.

Following the formation of AfREN in Nairobi 2006, GARNET was re-launched in November 2006 at the end of a three day NREN workshop organized by AAU in Accra. GARNET produced an MoU to be signed by VCs and an Action Plan. The MoU was, however, never signed and the process stalled.

The Interim executives of GARNET that prepared the MoU concluded, after several discussions with interest groups, concluded that a “bottom-up” approach should be adopted to accelerate the formation of GARNET. Following the Nigerian experience, the formation of a Forum was suggested involving all stakeholders willing to participate in the formation of the National Research and Education Network (NREN) for Ghana.

A Workshop sponsored by AAU was organized in July 2008 at the University of Ghana at which it was decided to set up the GARNET FORUM (www.garnet.edu.gh). Presentations showed that the institutional networks of the members had improved and information about extensions of the emerging national fibre backbone (NCBC) gave hope for an increasing interest to get GARNET established. Members were invited to submit requirements for backbone services.

A plan of action for the next five months was evolved to deal with administrative matters and produce a technical plan, including requirement specifications for procurement of infrastructure services and equipment as well applications to Afrinic for assigned numbers and necessary licenses/permits from the regulator.

The constitution of GARNET is expected to happen at a next workshop early 2009. Points of contacts are Prof. Mumuni Dakubu, interim chair and Benjamin Eshun, interim secretary.

The pioneering members of GARNET include the institutions in the following list:

<table>
<thead>
<tr>
<th>Institution</th>
<th>City</th>
</tr>
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<tbody>
<tr>
<td>Ashesi University College</td>
<td>Accra</td>
</tr>
<tr>
<td>Central University College</td>
<td>Mitsos, Accra</td>
</tr>
<tr>
<td>Council for Scientific and Industrial Research</td>
<td>Accra</td>
</tr>
<tr>
<td>Ghana Institute of Management and Professional Studies</td>
<td>Accra</td>
</tr>
<tr>
<td>Ghana Telecom University College</td>
<td>Accra</td>
</tr>
<tr>
<td>Kwame Nkrumah University of Science &amp; Technology</td>
<td>Kumasi</td>
</tr>
<tr>
<td>Methodist University College</td>
<td>Accra</td>
</tr>
<tr>
<td>University of Cape Coast</td>
<td>Cape Coast</td>
</tr>
<tr>
<td>University of Development Studies</td>
<td>Tamale</td>
</tr>
<tr>
<td>University of Education, Winneba</td>
<td>Winneba</td>
</tr>
</tbody>
</table>

As illustrated in the figure below, the campuses involved are located nicely in relation to the existing and planned fibre infrastructure [Barfi]
Telecommunication service providers
Ghana Telecom was recently partly privatized and is now jointly owned by Vodafone (70%) and the Government of Ghana (30%). The deal includes the National Communication Backbone Company (NCBC) which will, however, remain an independent body leasing fibre and/or capacity on an open market on non-discriminatory conditions and support socio-economic development by providing access to the national fibre backbone also in rural areas of less commercial interest.

There are several Internet Service Providers. There was an Internet exchange point established in Accra Ghana becoming operational in October 2005 in the AFIX programme supported by DFID (www.gispa.org.gh).
The supply chains for computers and networking equipment seem to be well developed in Ghana.
4.13 Togo
Population ~ 5,858,673 (2008), francophone, one of the 15 ECOWAS members

**Policy and regulatory framework**
Telecommunications policy is managed by the Ministry of Post and Telecommunications. The independent regulator, L'Autorité de Réglementation des secteurs des postes et de télécommunications (ARPT), was formed in 1998 as part of the deregulation.

**Existing and planned fibre infrastructure**
Togo Telecom introduced fibre optic rings in Lomé and Kara 1992 and has a 750 km fibre optic cable linking Aného-Lomé-Kara-Cinkassé providing an STM16 service.

**Communication service providers**
Togo Telecom runs the only nationwide Internet backbone in the country. There was an Internet exchange point established in Lomé becoming operational in April 2006 in the AFIX programme supported by DFID.

**NREN Maturity**
Togo has two universities, both in Lomé. There is no response to our request for information about an emerging NREN formation process.

4.14 Benin
Population ~8,532,547 (2008), francophone, one of the 15 ECOWAS members

**Stakeholders in research and education networking**
In Benin we talked to Benin Telecom, yet to be privatized, the Ministry of Communication and the coordinator of NREN activities at University of Abomey.

**Policy and regulatory framework**
The regulatory environment in Benin is expected to be permissive regarding a dedicated non-commercial research and education network. The representative from the Ministry of Communication we talked to wanted, however, to have a written request and a plan showing the intentions of the NREN before committing to anything.

**Existing and planned fibre infrastructure**
Telecom Benin is operating a SAT-3 landing point and has deployed optical fibre to the borders of Togo, Niger and Burkina Faso. They are also connected to an optical fibre from Nigeria owned by Suburban Telecom. The representative we talked to said he would be prepared to endorse a project proposal giving an NREN access to a wavelength for strictly non-commercial purposes, provided the NREN could demonstrate innovative technical solutions.

**NREN Maturity**
Benin has two universities, University of Abomey-Calavi, with campuses in Abomey-Calavi, Cotonou, Dangbo, Lokassa, Ouidah and Porto Novo, and University of Parakou, with one campus in Parakou. The Benin Telecom fibre cable passes within 5-15 km of some of these campuses.

**Communication service providers**
The incumbent, Benin Telecom (www.opt.bj) maintains the SAT-3 landing point in BENIN, has a national fibre backbone deployed which extends to the borders of Togo, Burkina Faso, Niger and Nigeria.
There was an Internet exchange point established in Cotonou becoming operational in October 2005 in the AFIX programme supported by DFID.
4.15 Niger

Population ~13,272,679 (2008), francophone, one of the 15 members of ECOWAS

**Stakeholders in research and education networking**

Besides the policy makers and regulators in the research and higher education area and in the communication area, the research and higher education institutions, as well as other users of communication infrastructure, and ICT industry, including Sonitel, Orange, Celtel/Zain, Telecel, Nigernet. ISOC has an active representation in Niamey.

**Policy and regulatory framework**

The policy maker in the ICT area in Niger is the Minister of Communications and the independent regulator is Autorité de Regulation Multisectorielle (ARM) of Niger (www.arm-niger.org), a member of WATRA.

According to WATRA, an NREN organisation would probably not need a license for the establishment and operation of a dedicated non-commercial network serving only research and higher education institutions, as long as they use infrastructure (digital links, optical wavelengths or dark fibre) belonging to licensed operators. We have however, not yet been able to confirm this with the national regulator in Niger, ARM.

**Existing and planned fibre infrastructure**

A high-speed fibre optic network has been installed in Niger (www.azom.com/News.asp?NewsID=7211) for Sonitel. A fibre-optic loop in the Niamey area with links to the borders of Burkina Faso and Benin, and further to the SAT3 undersea cable was inaugurated in 2006. In a second phase a high-capacity access backbone will be installed, consisting of a central fiber-optic loop and various client loops for major Sonitel customers. The infrastructure is installed by Siemens, including the passive elements such as the optical cables, the active elements such as communication systems for enterprises and a TNMS-M network management system. In 2005, the DOMSAT (Domestic Satellite) satellite backbone operated by Sonitel was digitized. DOMSAT connects Sonitel’s fixed telephony network and the SahelCom mobile network with the capital Niamey, thereby also linking people in Diffa, Agadez and Bilma.

Are there any fibre maps? Other fibre owners? Any of the cellular operators? Electricity company? Any pipelines?

In the longer term, two projects planning to deploy optical fibre along the emerging trans-African Highway system are of interest, in which Niger plays important roles:

- Route 2 Algiers – Tamanrasset – Agadez – Kano – Lagos
- Route 5 Dakar - Bamako – Ouagadougou – Niamey – Kano - Ndjamen, where the currently missing links are Ouagadougou to the Niger border and from Niamey – Kano – Ndjamen
- Route 6 from Ndjamen via Kosti in Sudan to Djibouti where the missing link is through Chad.

**NREN Maturity**

Niger has one university, Université Abdou Moumoun (UAM), located in the capital, Niamey. Other potential NREN members include African Centre of Meteorological Application for Development (www.acmad.ne) and the Regional Institutes of Technology in Maradi, Tahoua and Zinder. There are also two public higher schools and another private.

We conclude from our correspondence with our contact at UAM that the current Internet Service Provider offers international access via SAT-3 and France Telecom Worldwide IP Backbone (Opentransit – AS5511).

Although we have some indications that there is an NREN discussion in progress, we have not yet been able to see a comprehensive baseline report from the research and higher education community in Niger describing the current status nor an NREN formation plan.

**Communication service providers**

Niger privatised the incumbent Sonitel (www.intnet.ne, www.sonitel.ne) in 2001, then 98% owned by the state and employing 1,300 people, after several attempts that failed to attract
bidders. The government of Niger kept 34% after the privatisation, with 11% being sold to Niger nationals and 3% distributed amongst staff. The Chinese company ZTE (www.en.zte.com.cn) has a 51% stake in both Sonitel and its mobile arm, SahelCom. Sonitel's fixed-line network capacity 2001 was 25,000 lines which the government wants to increase to 77,000 by 2010.

In August 2001, ZTE won a contract to convert Sonitel's mobile arm Sahel Com to the GSM standard, making it the third mobile operator with a GSM licence along with cellular operators Telecel and Celtel.

Internet Service Providers
Sonitel (www.intnet.ne) and Nigernet (http://nigernet.com/)

4.16 Nigeria
Population ~146,255,312, anglophone, one of the 15 ECOWAS members

Stakeholders in research and education networking
Being the largest country in Africa, Nigeria is often in a category of its own from most aspects related to this study. The fact that it is probably also one of the most open and competitive communication market in Africa, adds a lot of dynamics to this picture, which creates both opportunities and challenges.

Besides the policy makers and regulators in the research and higher education area and in the communication area, the research and higher education institutions, as well as other users of communication infrastructure, and ICT industry, including NITEL, Globacom, MTN Nigeria, Zain, Suburban.

Policy and regulatory framework
Policy-wise, there seems to be support, both from the education and the communication sectors, for the ongoing process to establish an NREN i Nigeria to be connected to a regional and global research and education infrastructure. Earlier top-down attempts have, however, failed, maybe for lack of trust between stakeholders and as well as a lack of understanding of the nature of the global infrastructure for research and higher education. These networks are in many ways extreme and, in order to fulfil their roles, African universities need access on an equal footing with their international peers. Thus they should not be bundled together with other public sector users.

The current process is conducted bottom up using the “ng ICT Forum”-framework (www.forum.org.ng) in which important capacity-building activities in terms of education and training in internetworking take place. This arrangement also serves the purpose to raise the awareness that there is a drastic shift of technology going from simple low-capacity transit to the Internet using individual VSATs, to a cooperative high-capacity multi-homed network environment with equal shares of academic peering and Internet transit.

According to WATRA, the Nigerian regulator, NCC, is together with its Ghanaian colleague, enforcing the most developed and open regulatory framework of the anglophone countries in W&C Africa.

Existing and planned fibre infrastructure
Nigeria is generally considered the most competitive fixed-line market in Africa with a second national operator, Globacom, and over 50 other companies licensed to provide fixed telephony services. According to the same source, the alternative carriers combined now provide over 95% of all fixed lines, the majority being implemented by wireless technologies, giving the network operators the opportunity to also enter the lucrative mobile market under a new unified licensing regime, which has helped them to secure very large in investments from local and foreign investors. Several microwave and fibre-based national backbone infrastructures are being rolled out by various companies and new international submarine fibre optic cables are scheduled to arrive in Nigeria 2009, which will also deliver a major boost to the underdeveloped Internet and broadband sector.

The second Network Operator, Globacom, has an aggressive national fibre deployment program and is also deploying a new submarine cable from London with landing points planned in Dakar, Accra and Lagos, becoming operational in March 2009. The wireless
operators MTN and Zain are also expanding into the broadband market with both a fibre to the pole and a mobile broadband strategy. They have all deployed more than 5000 km each and are still extending their networks. Suburban telecom is another fibre owner that has focussed on providing transborder traffic in the region, carriers carrier services and has 10Gbps connection to London. There is also fibre deployment in progress in the power grid and along pipelines.

**NITEL (www.nitel.com)**
The recently privatised incumbent, Nitel, generally described as moribund, is looking for new investors and business models. NITEL is in control of the SAT-3 landing station in Lagos but seems currently not able to provide competitive services and are forcing their competitors to find alternative solutions.

**Globacom (www.gloworld.com)**
Globacom is in the process of deploying some 10,000 km in a first phase in Nigeria. The intention is to provide a reliable voice-and-data transmission medium offering high-speed transmission of point-to-point voice, high-speed data, fax and video and provides large bandwidth for offices and corporate organizations. The infrastructure will be made available to other telecommunication companies, internet service providers, individual businesses, manufacturers, oil companies, banks and financial institutions, governments and other corporate organizations.

The Globacom fibre network is deployed along the following routes: Ibadan-Abeokuta-Lagos-IjebuOde-Ore-Benin-Sapele-Warri-Kaima(Yenegoa junction)-Port Harcourt-Aba-Owerri-Enugu-Awka-Onitscha-Owerri and Minna-Abuja-Kaduna-Zaria-Kano. Eket, in the south-east Akwa Ibom State, was recently connected. Other routes to be covered in the first phase of the project include Ibadan-Ilorin-Jebba-Mokwa-Bida-Minna-Abuja-Lafia-Markudi-Oturkbo-Enugu

Globacom’s fixed line network, Broad Access, which will soon commence commercial services, will run on the optic fibre platform and will transform the country’s underdeveloped fixed line telephony. In the initial launch phase, fixed line services would be available in 13 major cities in Nigeria with a capacity of 300,000 lines.

**MTN-Nigeria (MTNN)**
The MTNN network is depicted in the diagram below: MTN has access to the Internet backbone via SAT-3, but not via NITEL
MTNNs national fibre optic transmission network has been planned to consist of three fully-
protected STM-64 (10Gbit/s) DWDM rings in the North, South and South East sections of
Nigeria. The fibre backbone consists of 32 core fibre optic cables of G.652 and G.655 fibres.,
deployed in three physical ducts. Only one fibre pair is currently in use.

MTNN has standardized on Huawei’s Intelligent Optical Networking Solutions. In addition to
the physical network, a Dense Wavelength Division Multiplexing (DWDM) system has been
installed that allows for high capacity circuits to be provided on the network. The current
system consists of multiple link capacities (or lambdas), these being a 10 Gbit/s, STM-64
Core Inter-Regional Layer, a 2.5 Gbit/s, STM-16 Add-Drop Layer for BTS Traffic, and a
Gigabit Ethernet (GE) Layer for the MTNN IP/MPLS Backbone. This can be expanded to a
total of 40 x lambdas, each modulated at 10 Gbit/s., providing a total current capacity of 400
Gbit/s. The capacity can be expanded up to 160 x lambda’s, giving a total capacity of 1.6
Terabit/s, before an additional fibre need to be utilized. Huawei has announced interface
cards modulated at 40 Gbit/s, allowing for significant additional capacity to be added to the
system.

The transmission network is based on STM-64 (10 Gbit/s) bandwidth and is also switching
both STM-16 (2.5 Gbit/s) and Gigabit Ethernet (GE) traffic on the same infrastructure,
utilizing the deployed DWDM infrastructure. Services supported by the network include SDH
STM-1/4/16/64, SONET OC-3/12/48/192 and Gigabit Ethernet and more.

**Zain**
The construction of a 4,000 km fibre-optic transmission backbone expected to be completed
by mid 2009, including an already operational fibre optic cable connecting Port Harcourt,
Enugu, Asaba, Lagos and Abuja. Pending the completion of its own infrastructure, Zain is
leasing fibre-optic capacity across the country. At the same time, the existing 3,000 km
microwave transmission backbone is extended to 5,000 km. Zain has doubled its base
stations in the country from 1,100 in 2006 to 3,400 at the end of the second quarter of 2008,
with an additional 500 base stations built in the second quarter of the year to achieve full
coverage of the six geographical zones of the country with new switches installed in in Abuja,
Enugu, Kaduna, Kano, Bauchi and Benin City.

**Suburban Telecom**
Suburban Telecom (www.suburbantelecom.com) is another fibre owner targeting the
Corporate sector having deployed about 1000 km in Nigeria up to now as well as transborder
to Benin. Via swap deals and other agreements, Suburban has access to regional fibre
between Nigeria and Dakar, and a 10Gbps connection to a European hub n London.

**Communication service provider**
The 65 MUSD NEPSKOM telecommunications project recommenced in February 2004.
Eskom has a 51% share in this project which involves the operation of a long-distance
telecommunications licence, with telecommunications fibre laid on the Nigeria Electricity
Power Authority (Nepa) transmission infrastructure. EEGWA had to ensure this had the full
support of Nepa, the Nigerian Ministry of Power and Steel, and the Nigeria Communications
Corporation. EEGWA hope to begin conveying traffic on this telecommunications network
by end February 2004.

**Internet Service providers**
In April 2006 there was an ISP Association formed in Nigeria (www.ispan.org.ng) and an
Internet Exchange point established (www.nixp.net).

**NREN Maturity**
The NREN formation process in Nigeria is being mid-wifed by the Nigeria ICT Forum
although the NREN itself in the end has to be under the control of the united research and
tertiary level education institutions. Besides such institutions, the members of the Forum
include ISPs and other organisations collaborating in the ICT field.

Promoted by AAU, the research and higher education community of Nigeria, decided during
the first ngNOG event inspired by AfNOG, in Kano in November 2007 to take on the
challenge to create the NREN, before the end of 2008. At a meeting in Abuja in February
2008, a meeting of VC and authorities of institutions of higher education took place on NREN feasibility and access to bandwidth at low cost. It was also decided to follow up on the implementation by Nigeria ICT Forum under the supervision of the chairperson of the AVCNU (Association of VC of Nigerian Universities). As of Mid/2009, the process is not yet formalised.

In our opinion, the main challenge is the scale. There seems to be almost a hundred universities involved, including both public and private, and in total 450 institutions. It seems important that this process should go on in parallel with the formation of a regional network, not to delay the development in other countries in the region.
5. Country analysis Central Africa (CEMAC member states)

CEMAC - Communauté Économique et Monétaire de l’Afrique Centrale (www.cemac.cf)

5.1 Chad

Population ~10,111,337 (2008), francophone, arabic

Policy and regulatory framework
Policy in the telecommunications area is formulated by Ministère de Postes et Télécommunications Ministry (www.tit.td). The independent regulator is Office Tchadien de Regulation des Telecoms (OTRT) (www.otrt.td)

Existing and planned fibre infrastructure
There is an optical fibre cable along the oil pipeline from Doba in Chad to the marine terminal in Kribi, Cameroon.

NREN Maturity
There is no response to our requests for information and no sign of an NREN formation process in Chad.

Communication service providers
Mobile-phone subscribers rose from some 26 000 in 2000 to about 500 000 in 2006 (6.3 per cent of the population), while the number of fixed lines (13 000 operational, or 0.2 lines for every 100 inhabitants) has hardly changed and remains well below the African average of 5 per 100 inhabitants.

A rural phone project has installed VSAT stations in 15 secondary towns. Telecoms access should also grow with the laying of a 1 200-kilometre 2.5 Gbps fibre-optic cable along the country’s oil pipeline as part of the national oil project. Chad has fewer than 300 public-phone booths and not many call centres. Internet access is through Sotel Chad’s Tawali and the mobile-phone operator Tigo, but is expensive.

5.2 Cameroon

Population ~18,467,692, anglo and francophone

Stakeholders in research and education networking
As described below in more detail, the policy-makers are very much involved in the formation of an NREN in Cameroon.

Other main stakeholders include the producers on the communication market, primarily the incumbent telecommunications operator Camtel, as well as the universities.

Policy and regulatory framework
The Ministry of Higher Education (www.minesup.gov.cm) is active in creating a cooperation between the universities to achieve joint procurements of VSAT capacity via CITI and RIC, Reseau Inter-universitaire de Cameroon. This cooperation may eventually turn into an NREN.

The telecommunication regulator “Agence de Régulation des Télécommunications” (ART) was created 1998-07-14 by law 98/014 controlling the telecommunications sector in Cameroun. ART is an independent public agency with an organisation and responsibilities defined in décret 98/197 from 1998-09-08. ART has its head quarters in Yaoundé and local offices in Yaoundé, Douala and Garoua.
Camtel (www.camtel.cm)
Camtel is the incumbent national telecommunications and Internet service provider in Cameroon. The Camtel network includes optical fibre between Douala and Yaounde and between Kribi and Lolodorf. Camtel also operates satellite earthlink stations in Bepanda, Zamengoe and Garoua. According to the company website the highest capacity available for leased lines is 2Mbps. The price is between 6-10 k€/month depending on distance. High capacity links (1-10GE), wavelengths or dark fibre are not offered. Camtel also operates the optical fibre along the oil pipeline between the marine terminal in Kribi – Bipindi – Lolodorf - Ngoumou, Youndé – Batchenga – Nanga Eboko – Belabo – Deng Deng – Meiganga – Touboro, cross border to Chad to Bajbokum - Komé – Doba where the oil field is located.
NREN Maturity
There are seven universities in Cameroon involved in the NREN discussion: University of Buea, University of Douala, University of Dschang, University of Maroua, University of Ngaoundere, University of Yaounde I and University of Yaounde II. The University of Yaounde was split into two separate institutions in 1993 as a result of the growing number of students, and the need to distribute higher education opportunities more evenly across the country. In addition, a private university, technical and professional schools, and a number of teacher training colleges have been established in recent years.

RIC, Reseau Inter-universitaire du Cameroun, was created in Yaoundé 2006-06-16. The infrastructure currently used to link the universities and provide Internet connectivity is VSAT links. In 2007, seven institutions were interconnected to RIC: CITI, UY1, UY2, Buea, Douala, Dschang and Ngaoundéré. The legal framework for RIC is stipulated in Arrêté du MINESUP, N° 06/0071 from 2006-06-19, creating CITI (www.minesup.gov.cm). At a RIC Forum meeting in Yaoundé, in April 2008, the use of optical fibre for interconnection of campuses instead of VSAT in partnership with CAMTEL (www.camtel.cm) was discussed. The focal point is the Computer science Unit at the Ministry of Higher Education.

An Internet Exchange Point workshop was held in July 2006 as part of the CATIA program. Studies for the implementation of an IXP are now underway by the National ICT agency.

5.3 Central African Republic
Population ~4,444,330 (2008), francophone

Policy and regulatory framework
Policy in the telecommunications area is set by Ministere des Postes et des Telecommunications and the regulator is Agence chargée de la Régulation des Télécommunications (ART).

NREN Maturity
There has been no response to our requests for information about university networking.

5.4 Equatorial Guinea
Population ~ 616,459 (2008), hispanophone and francophone

Existing and planned fibre infrastructure
Digital fixed-line network in most major urban areas and good mobile coverage
Fixed-line density is about 2 per 100 persons; mobile-cellular subscribership has been increasing and in 2005 stood at about 20 percent of the population. International communications from Bata and Malabo to African and European countries; satellite earth station - 1 Intelsat (Indian Ocean)

NREN Maturity
Universidad Nacional de Guinea Ecuatorial (UNGE) located in Malabo on Bioko Island has cooperation with universities in Spain, including Universidad Nacional de Educación a Distancia (UNED), and OEI (www.campus-oei.org/guiauniv/gui001.htm).
There has been no response to our request for information regarding NREN activities.

Communication service providers
Wireless services of France Telecom's GETESA (Equatorial Guinea), Sonatel (Senegal), and Ikatel (Mali) have been rebranded under the brand name Orange. France Telecom owns 40 percent of fixed-line and wireless service provider GETESA, having a monopoly in wireless services for the Equatorial Guinea region.

5.5 Gabon
Population: ~1,485,832 (2008), francophone

Policy and regulatory framework
The regulator is Agence de Regulation des Telecommunications (www.artel.ga)
**NREN Maturity**

We have got no response to our requests for information about university networking.

**Communication service providers**

The incumbent operator Gabon Telecom has still a monopoly on fixed network services. It also has a mobile communication subsidiary, Libertis. There are two independent mobile operators, Zain and Atlantique Telecom Gabon. There are some ten ISPs, all dependent on access from the incumbent. An Internet Exchange Point, IXP, was established in Gabon in August 2006 as part of the CATIA program.

**5.6 Congo Brazzaville**

Population ~3,903,318 (2008), francophone

**Policy and regulatory framework**

There is yet no independent regulator. Telecom policy and regulation is managed by the Ministry of Communication.

**Infrastructure**

The telecom infrastructure is poor. Mid-2007, the total data capacity to the country was 256 kbps. There were only 200 dial-up Internet subscribers and one Internet service provider in the country [infoDev2007]. The incumbent, Société de Télécommunications du Congo (Sotelco) is the main provider of basic telecommunication services.

The licensing system for VSAT in the Congo offers two alternatives: Sotelco can be designated as the recipient for the satellite circuit charges, in which case it adds 5% before passing them on to the user. If Sotelco is not included, an annual licence fee of about USD$8,000 monthly fee of about USD$3,300 is required.

**NREN Maturity**

The main potential NREN members include Université Marien Ngouabi and the research institute CERVE. There has, however, been no response to our request for information regarding NREN activities.

**Communication service provider**

Mobile operators include Zain, MTN and Warid. An Internet Exchange Point, IXP, was established in Brazzaville in August 2006 as part of the CATIA program.

**5.7 Sao Tomé and Principe**

Population: ~206,178 (2008), Lusophone

**Stakeholders in research and education networking**

**Policy and regulatory framework**

There is recently an independent regulator but the market is still a monopoly.

**NREN Maturity**

There are two higher education institutions, Instituto Universitário de Contabilidade Administração e Informática (IUCAI), which is a private institution founded 1994 with funding driven primarily by tuition and Instituto Superior Politécnico of São Tomé and Principe (ISP), a public institution founded 1997 where 90% of its budget is provided by the state. There is no response to our request for information about research and education networking.

**Infrastructure and Communication service providers**

The country has a telecommunication infrastructure and full Internet services are being developed by the national telecom, the Companhia Santomense de Telecomunicações (CST), of which 51 percent is owned by Portugal Telecommunications International (PTI). Tecnologia de Sistemas Informático is the main enterprise of the local computer community and it is jointly administered with Bahnhof Internet AB of Sweden.
This map illustrates the plans for highway roads across the African continent. The marginal cost for adding optical fibre cables along this infrastructure is marginal and should be seen as an investment in the telecommunication sector. It is, however, often hard to get this cross-cutting cooperation between the different stakeholders in the two sectors.
This map is illustrating the planned high voltage power lines in West Africa. Fibre cables are deployed in such networks for Supervisory Control And Data Acquisition (SCADA) purposes and redundant fibre pairs are normally made available for other users. Sometimes owners of this kind of infrastructure hesitate about the business model to use for doing so with the consequence that much of the available fibre is being unused. Regulatory challenges can also contribute to this unfortunate situation.