American Journal of Engineering and Technology Management
2022; 7(5): 75-85
http://www.sciencepublishinggroup.com/j/ajetm
doi: 10.11648/j.ajetm.20220705.11
ISSN: 2575-1948 (Print); ISSN: 2575-1441 (Online)

Enabling Ubiquitous Global Communications in Equatorial Guinea Via the Transformation of Getesa

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To cite this article:
Oscar Ondo Ngomo Nchama, Christopher Chatwin. Enabling Ubiquitous Global Communications in Equatorial Guinea Via the Transformation of Getesa. *American Journal of Engineering and Technology Management*. Vol. 7, No. 5, 2022, pp. 75-85.
doi: 10.11648/j.ajetm.20220705.11

Received: November 27, 2022; **Accepted**: December 14, 2022; **Published**: December 28, 2022

Abstract: This paper focuses on the modernization of the first national Mobile Network of Equatorial Guinea, called GETESA. The government's decision to invest and take full control of the network was motivated by the lack of network quality, which had poor capacity, with 69% of the network coverage Received-Signal-Code-Power (RSCP) below 95dMm. For the past 30 years, France Cable did not invest in modernizing the network; neither did they transfer the know-how to Equatorial Guinea nationals. The GETESA Radio access network equipment was outdated and could not support future Long-Term Evolution (LTE). None of the existing equipment could be taken into consideration for any potential upgrade of the network. This is mainly because of: low durability and reliability, High Operational Expenditure (OPEX) on maintenance, Impact on business, old equipment cannot support Future Expandability. It was therefore necessary to modernize the network by installing the latest hardware and software to build a multi-technology system with a convergent Radio Access Network (RAN) supporting LTE evolution and provide more flexibility for service deployment by adopting multimode. In addition to network evolution, a single RAN provides a simplified network topology, deployment, operation, and maintenance: one base station and one controller for multiple technologies. The Swap from 2G to 3G is at 89% with 134 modernized base station while the Roll-Out of 4G is at 94% with 87 LTE base stations implemented. The modernization project has transformed GETESA to be a more effective and profitable company. This modernization program has had a positive effect on the economy of Equatorial Guinea.

Keywords: Communication Technology, Mobile Network, Equatorial Guinea, GETESA, Modernisation

1. Introduction

Information and Communication Technology (ICT) technology is reshaping the world and becoming a new force leading to the next phase of global human societal evolution. ICT, particularly: mobile broadband, cloud computing, Big Data analytics, the internet of thins (IoT), and social networking, are making the interaction connection more flexible, agile, diversified, and rapid. Ubiquitous connectivity, whether it is data or voice, is now the global norm increasingly users want low cost, high quality, and reliable communication services from their service providers. This paper focuses on the modernization of the first national Mobile Network of Equatorial Guinea, called GETESA. Equatorial Guinea has three telecommunication companies: GETESA, Muni and Gecomsa. Getesa is the largest and the historical Equatorial Guinea telecommunication company established in 1987.

The Government of Equatorial Guinea holds 60% of the company whereas France Cable held 40% until it transferred its shares to Orange in 2010.

France Cable was in charge of all the main managerial positions (General Manger, Finance Department, and Technical Department) until 2012 when the government decided to buy back the 40% shares due to bad management. The government's decision was also motivated by the lack of network quality. In addition to this, for the past 30 years, France Cable did not invest in modernising the network, neither did they transfer the know-how to Equatorial Guinea nationals.

The current situation with the network is critical and needs urgent attention from the government if the company is to survive. The overall network needs to be upgraded to a 21st century telecoms company, which means that there needs to be significant new investment [1, 2].

Having considered both the economic and technical status of the company, we did propose and selected Huawei Technology to achieve the greatly needed modernisation. The decision to work with Huawei is based on their state-of-the-art expertise in network and communication technology and their ability to manage projects and provide leadership in radio network design [3, 4]. Huawei is also an innovator in 5G technology and other technological areas which can add value to GETESA.

The GETESA Radio access network equipment was outdated and could not support future Long-Term Evolution (LTE) [5, 6]. For this reason, it was necessary to modernise the network by installing the latest hardware and software to build a multi-technology system with a convergent Radio Access Network (RAN) supporting LTE evolution and provide more flexibility for service deployment by adopting multimode Base Stations equipped with Software Defined Radio (SDR) Radio Frequency (RF) modules, allowing deployment of several RANs at the same frequency, such as Global System for Mobiles and Universal Mobile Telecommunication Services (GSM&UMTS) in the 900MHz frequency band [7, 8]. It should adopt multi-mode Universal Baseband Processing (UBBP) and the Universal Main Processing and Transmission (UMPT) which can flexibly support different RANs; thus, LTE deployment will not require additional control modules.

In addition to network evolution, a Single RAN will provide a simplified network topology, deployment, operation and maintenance: One Base Station and One controller for multiple technologies [9].

2. Challenges of the Existing Network

Most of the equipment in GETESA, has served for more than eight years and in some cases twenty years, without any upgrade. Therefore, the company could not provide the high-quality services that are needed by its users, neither could it compete. For the RAN, the company was using both Alcatel and Huawei technologies.

For Alcatel equipment: the RAN network 2G equipment has served for twenty years and the 3G equipment served for 8 years. The Public Switched Telephone Network (PSTN) fixed network provided by Alcatel was also very old to the extent that it could no longer be upgraded, nor could it support any expansion. Basically, any future development of the network and business was impossible.

For Huawei Equipment: the RAN network 3G equipment served for more than seven years; most of the main parts were already at the end-of-support; the same is true for the software version of the RAN network. For the core network, the software version for Policy and Changing Rules Function (PCRF) and the software version for the Mobile Switching Centre (MSC) are no longer supported.

None of the existing equipment could be taken into consideration for any potential upgrade of the network. This is mainly because of the following: Low durability and reliability, High Operational Expenditure (OPEX) on maintenance, Impact on business, old equipment cannot support Future Expandability.

2.1. Poor User Experience

We identified several issues with the company's 2G/3G network related to coverage, which was seriously impacting the user experience, Figure 1 illustrates the problems. From our survey, the user speed was below 1Mbps for 33% of the grid area. The capacity of the network could not ensure a good experience for business such as High Definition (HD) video streaming, file transfer or other similar services.

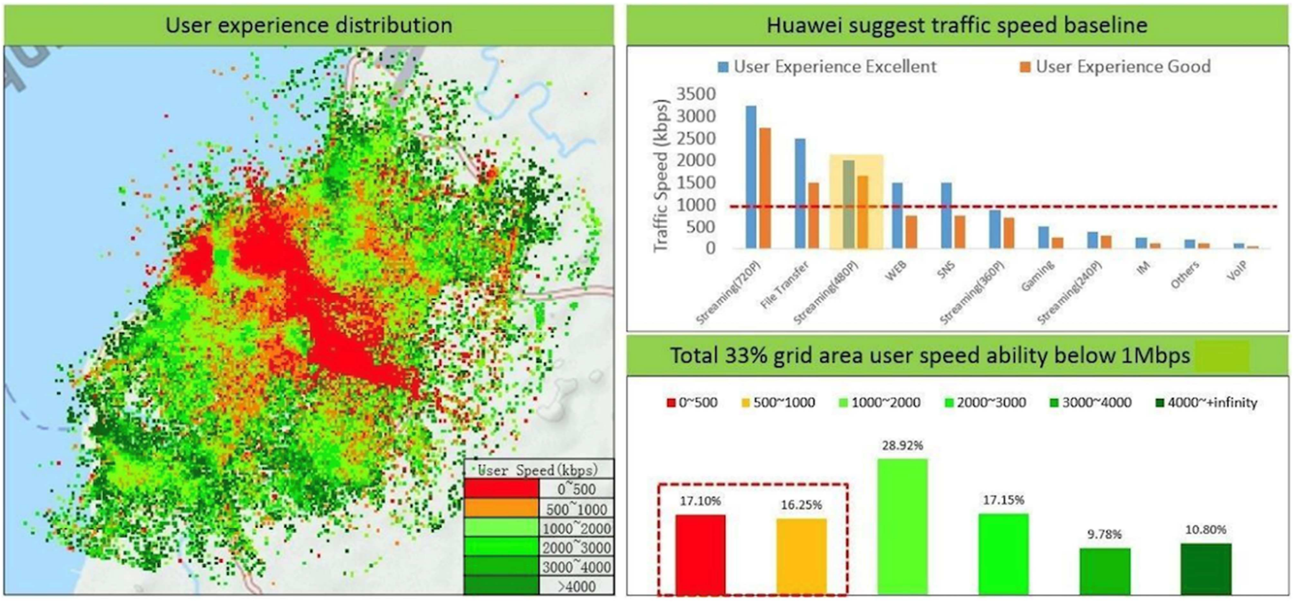

Figure 1. *User Experience Distribution.*

2.2. Capacity Congestion

We found several capacity problems in the network. The Radio Network Controller (RNC) on high load: all SPU Board

Communication Processor (CPU) of Bata_BSC1 exceeded 74%, as shown in Figures 2, 3 and 4.

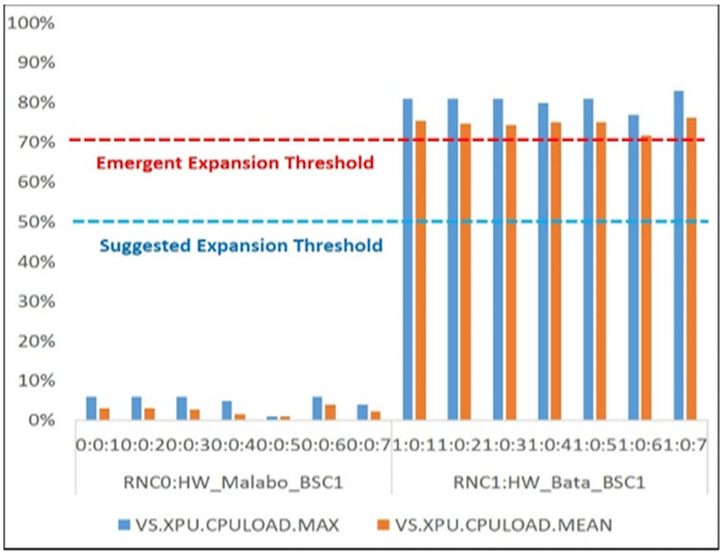

Figure 2. *Capacity Congestion.*

In many cells Transmission Control Protocol (TCP) exceeded 70% resulting in user access rejection.

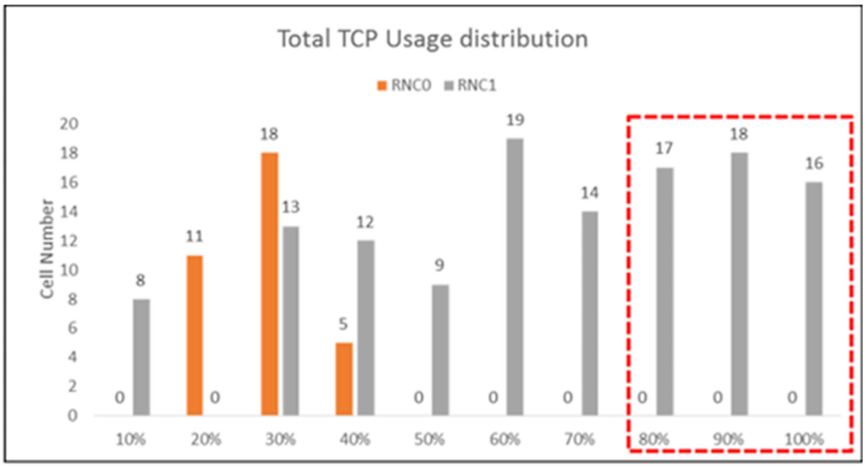

Figure 3. *Total TCP Usage Distribution.*

Many cells had inadequate Receive Total Wideband Power (RTWP) which resulted in poor user throughput.

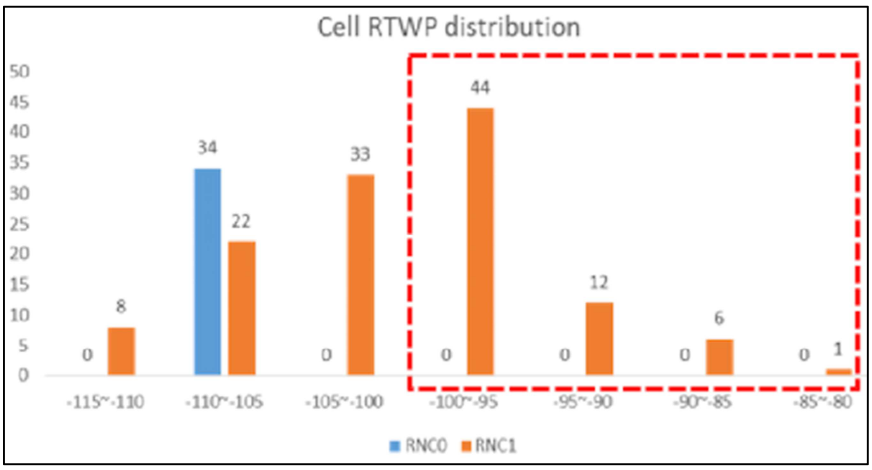

Figure 4. *Cell RTWP Distribution.*

2.3. Poor Coverage

Besides the capacity problem described previously, the company also had a serious problem of poor coverage of the network which also contributed to the bad user experience. For example, for 69% of the network coverage RSCP is below -95dBm as Figure 5 shows.

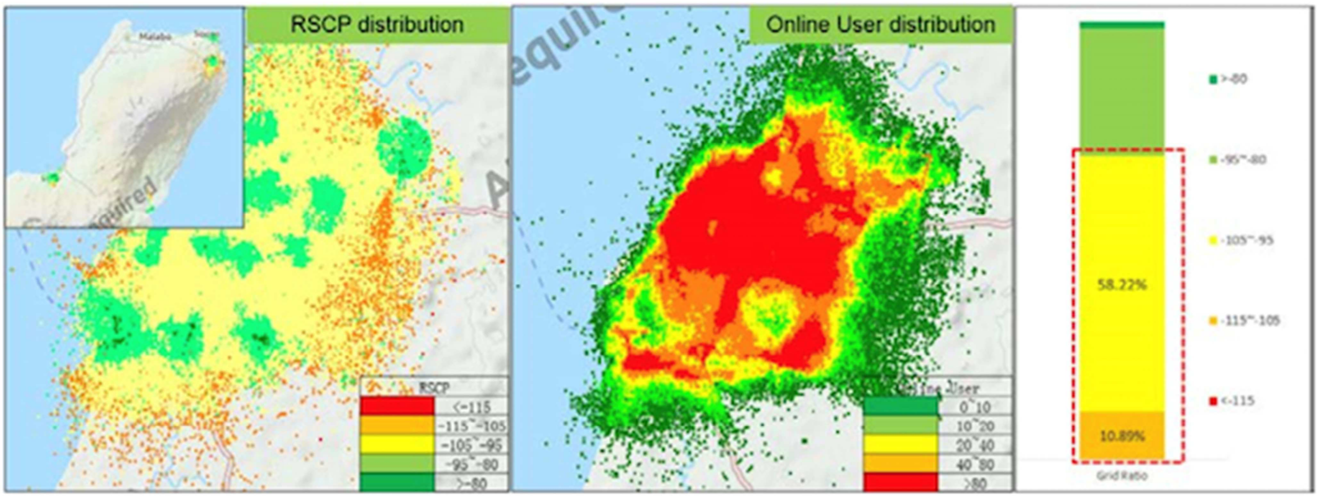

Figure 5. *Network Coverage is below -95dBm.*

56% of the coverage area quality is below <-12dB, which means that the interference in the network is high and coverage quality is poor as shown in Figure 6. As result of this, the communication quality and user access are being severely compromised.

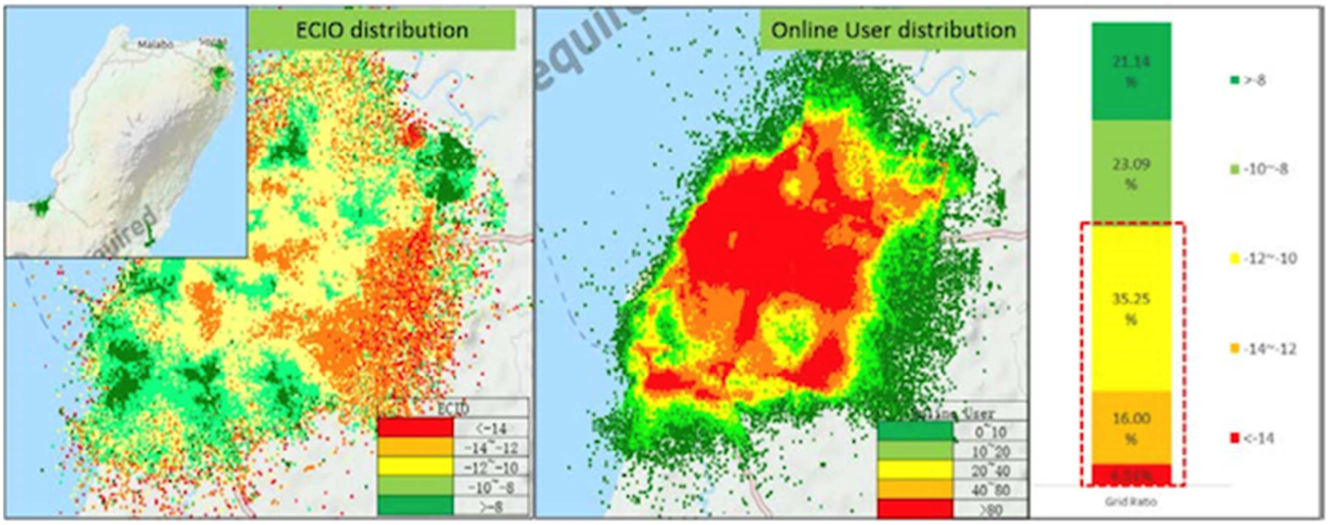

Figure 6. *Coverage Quality is below <-12dB.*

In addition to the above problems, the company was facing a poor user experience in other areas such as low speed, huge delay for service provision, poor response to customer complaints. In order to become competitive and boost the user experience GETESA badly needed complete network modernization to boost user experience and become more competitive. GETESA RAN equipment was outdated and could not support the future evolution of LTE. For this reason, it was necessary to modernise the network by installing the latest hardware and software to build a multi-technology and convergent RAN supporting LTE evolution and provide more flexibility for service deployment by adopting multimode Base Stations equipped with SDR RF modules [10-12].

3. Proposed New Radio Network

The aim of the proposed network is to boost the overall efficiency of the company and allow news services to be offered to the end users and provide a much higher quality user experience [13]. The proposed replacement network was implemented in phases:

Network Layout of Phase 1

Phase 1 concentrates on the capital of Malabo where the following system will be installed:

1) We considered 37 Multi-mode Base Stations and 1MBSC covering the entire area.
2) Replace the U2000 legacy SUN server with U2000 cloud-based server.
3) The existing antennas will be modernised using oriented Quad-Band Antenna with 2 low bands and 2 high bands.
4) Both the Core Network and IP core elements will be reused, and additional 48-port interface boards will be added to the existing NE40-X8 routers.

The above installations are going to enable the deployment of G1800, U2100, GU900 and it will facilitate the LTE800.

Network Layout Phase 2

Phase 2 concentrate on Bata which is the main economic city of the country, the following installations are planned:

1) 1MBSC, 121 BTS, 121 Node B, 10 eNodeBs for the Radio Access (RA) part.
2) The implementation of the GSM 1800MHz is considered in 33 sites.
3) The implementation of the UMTS 2100MHz is considered in 19 sites.
4) When it comes to the core network, meaning the CS&PS nodes should be upgraded to support LTE technology. Also, 48-port interface boards will be added to the two core routers in Bata.

Network Layout Phase 3

After completing the two first phases, we will implement the following systems:

1) The LTE800 will be deployed on the 82 sites implemented in phase one and two. The LTE800 only requires the addition of the Remote Radio Unit (RRU) for the 800MHz frequency band and the LTE software license.
2) For the core network part, the Evolved Packet Core (EPC) capacity is to be expanded.
3) The IP Multimedia Subsystem (IMS) will be deployed to allow Voice Over Broadband (VoBB) services.

Proposed IP Multimedia Subsystem

The proposed solution can completely meet GETESA's requirement for the target IMS architecture for the Public Switching Telephone Network (PSTN) modernization [14, 15]. Figure 7 below shows the mapping of the proposed solution to GETESA's architecture.

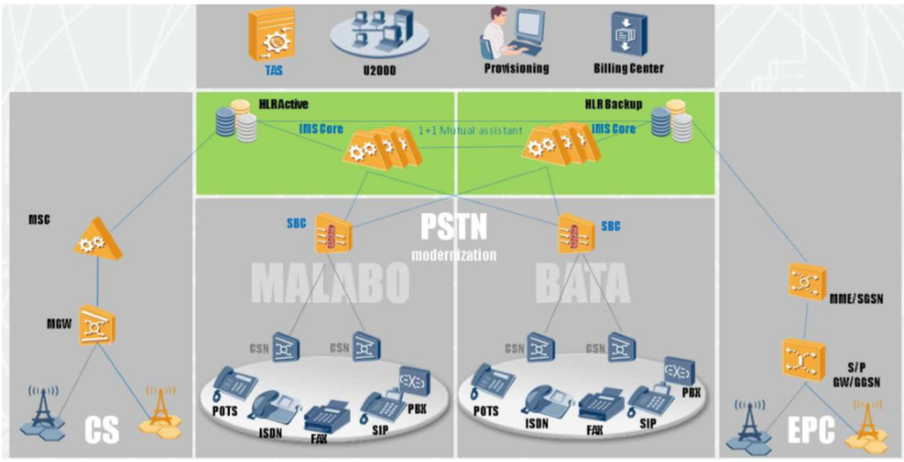

Figure 7. *Mapped Architecture.*

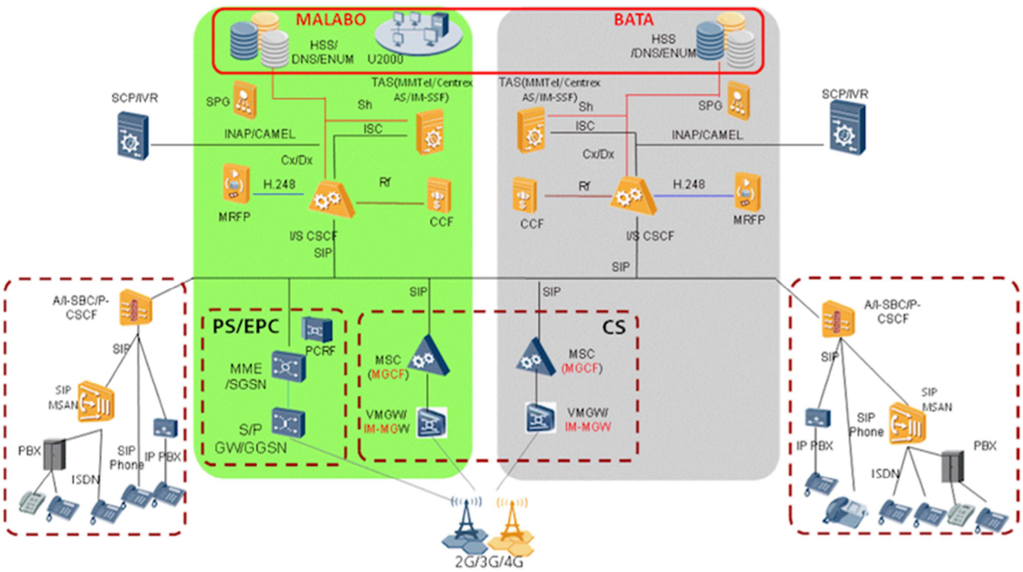

Figure 8. *Logical Networking Diagram.*

1) The fixed broadband (xPON/LAN/xDSL) VoBB subscribers access the IMS network through the SBC and P-CSCF, and IP PBX subscriber access the IMS network through the Session Border Controller (SBC) and the Base Station Control Function (BCF).
2) The ISDN (BRI, PRI) subscribers access the IMS network through the MSAN.
3) The fixed solution provides the following services:
   a) Real-time basic services: including basic voice, data (such as fax), convergent Centrex, etc.
   b) Value-added services: refer to value-added services provided by the traditional SCP or OCS, and IVR service.

The following Figure 8 shows the logical networking diagram both for PSTN modernization and Voice Over Broadband (VOBB).

The network structure complies with the IMS network construction specification of the operator while providing redundancy. The Network Elements (NE) on the service layer are deployed in one central site in a centralized manner. In addition, the signalling planes on the core layer are deployed in two sites to provide geographical redundancy while, the SBCs on the access layer are deployed on various local networks. The new NEs information is shown in the following Table 1 below.

Table 1. *NEs Information.*

Network Layer	Nodes	Functionality	Qty	Hardware	Remark
Application Server	ATS9900	TAS/IP Centre AS/IM-SSF	2	ATCA	New build.
Core Network	CSC3300	I/S/E-CSCF/MRFC	2	ATCA	New build.
	MRP6600	MRFP	2	ATCA	New build.
	SingleSDB	HLR/SAE-HSS/IMS-HSS/ENUM/D	2	ATCA	Reusing the existing HSS and upgrade from R8 to R10
Management and Charging	U2000	EMS	1	ATAE	Build New ATAE U2000 Functions as a unified element management platform.
	iCG9815	CCF Charging Function	2	ATCA	New build.
	SPG2800	Service Provisioning	2	ATCA	New build.
Access and Interconnect	SE2900	Gateway A/I-SBC/P-CSCF	2	MCCA	New build, Provide IP access and security for VOBB, LTE subs.
	MA5600T	MSAN	X	MA5600T	Provide POTS/ISDN subs access to IMS core.
	MSoftX3000	MSC/MGCF/SRVCC-IWF	2	ATCA	Upgrade current MSC to support MGCF and SRVCC-IWF function for IMS interconnect with other PLMN/PSTN, R9→R11.
	UMG8900	MGW/IM-MGW	4	SSM-160	Upgrade current MGW to support IMS interconnect with other PLMN/PSTN, R→R11.

The following Figure 9 shows the physical networking diagram while Figure 10 shows the topology of the target network in terms of internetworking with the existing network.

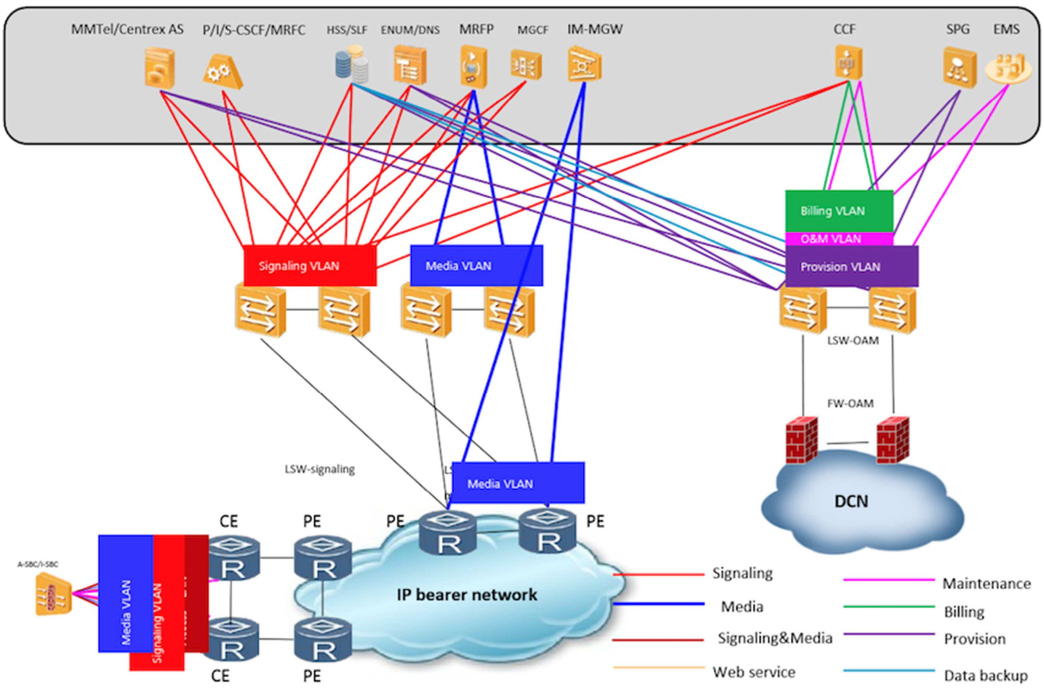

Figure 9. *Physical Networking Diagram.*

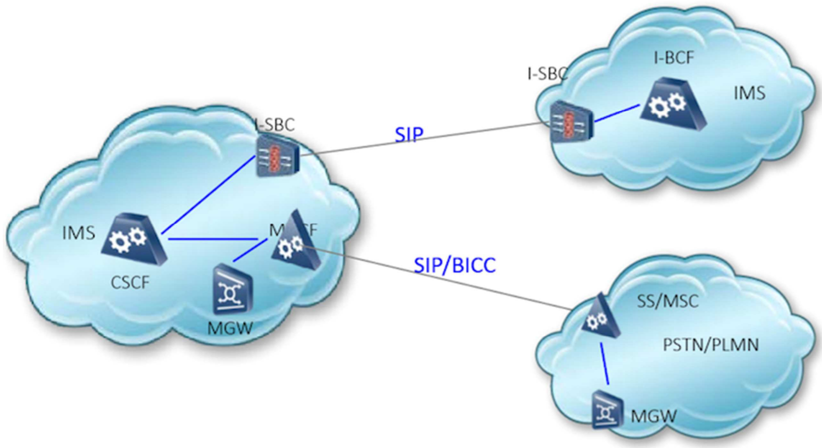

Figure 10. *Topology of Interconnection Network.*

1) Interworking with PSTN: The interconnection between the PSTN and IMS network is based on SIP/ISUP. If the SS support SIP interfaces, the SS can be connected to the Media Gateway Control Function (MGCF) directly. Otherwise, the SS must be connected to the MGCF through the Media Gateway (MGW). In addition, the MGW converts the voice media into IP packets. The MGW performs coding/decoding, assembly/disassembly and delay variation between Time Division Multiplexing (TDM) and VOIP and connects to the bearer network via standard 100M/1000M Ethernet interfaces.
2) Interworking with PLMN: The interconnection between the Public Land Mobile Network (PLMN) and IMS network is based on SIP or Bearer Independent Call Control (BICC).
3) Interworking with IMS: Two IMS networks are interconnected by the I-BCF based on SIP.

4. Benefits of the New Network

A lot of time has been spent working with the company on how the new upgraded company infrastructure will be operated, the company will now be more robust given the fact that new advanced technologies that are available. In addition to designing the network element, we also concentrated on making practical and economical network solutions. The following are the main benefits of the new network:

GMS/UMTS/LTE Radio Access Network Convergence: by modernising the legacy GSM network, GETESA will easily achieve multi-technology converged RAN thanks to the Huawei-fledged SingleRAN solution, which is field-proven and two years ahead of the competition and is applicable for GSM/UMTS multi-mode deployment and capable of smooth evolution from EDGE to HSPA to HSPA+ to LTE to LTE-A.

The Huawei SingleRAN solution is based on the 3900 series of GSMS/UMTS/LTE multimode base stations, GSM/EDGE (+)/UMTS/HSPA (+) multimode base station controller BSC6910, and the GMS/UMTS/LTE unified element management system iManager U2000. Through this multi standard converged equipment built upon the unified platforms, the company can be assured of a multi-technology converged RAN with the following features:

Easy and Flexible Introduction of LTE: by implementing the proposed Huawei SinglaRAN multimode BTS, powered by SDR and common platform design, the company is guaranteed to have a smooth transition to LTE.

Flexible GSM/UMTS and LTE Interworking: To ensure service continuity between GSM/UMTS and LTE in a network with both GSM/UMTS and LTE coverage, Huawei supports SRVCC, CSFB, Cell reselection PS Handover and eNACC PS handover to ensure service continuity. In this way GETESA can make full use of the advantages of both GSM/UMTS and LTE to provide satisfactory service quality.

Unified Network Management System: Huawei OSS supports unified management for multi-RAT (GSM, UMTS, and LTE) and multi-domain (RAN, CN, IP & Transmission devices, Site equipment, etc). It captures operators' maintenance experience for re-use across technologies and accommodates maintenance best practices, all of which can help the operator cope with inter-operational challenges and achieve the operational experience of "One OSS, One Team".

The new network design will enhance coverage and the number of sites will also be reduced therefore, the company will be very competitive and save the Total Cost of Ownership (TCO). Most of the leading operators around the world have adopted the latest enhanced coverage technology that can be used in both GSM/UMTS and LTE. As a result of this the coverage solution reduces the number cell sites by 30%.

5. Practical Results

The proposed solution presented here was adopted by the board of directors of GETESA and the following practical results were obtained:

Actions

1) More Capacity: adequate infrastructure and modernisation of 2G/3G Base Stations in the main cities.
2) *4G improved user experience* in mobile data browsing with LTE deployment.
3) *Fewer service incidents*: improved network stability in terms of equipment and energy.
4) *Less impact*: reduction of incident resolution time in the NOC (Network Operation Centre).

5) *More connected users*: competitive commercial strategy in mobile tariff offerings.
6) *3G and 4G network optimisation* and extension with 2nd carrier refarming in the 900 MHz band.
7) *Redundancy*: routing services and strategic network equipment.

Achievements

1) National traffic: GETESA's traffic volume has increased by +101% in 2021 as Figure 11 illustrates.
2) Mobile Traffic: Mobile network traffic volume has increased by +16% in 2021 as Figure 12 shows.
3) Mobile Customer: while the number of mobile users (SIM) has been increasing since the start of the modernization projects, in 2021 the increase slightly dropped by -0.19% as shown in Figure 13.
4) Package revenue: the data bundle has been increasing weekly and throughout 2021 at +22% in 2021 as Figure 14 illustrates.
5) Billing: GETESA's turnover has increased by +25% during 2019-2020.
6) Benefits: the profit of the company has increased by +90% during 2019-2020.

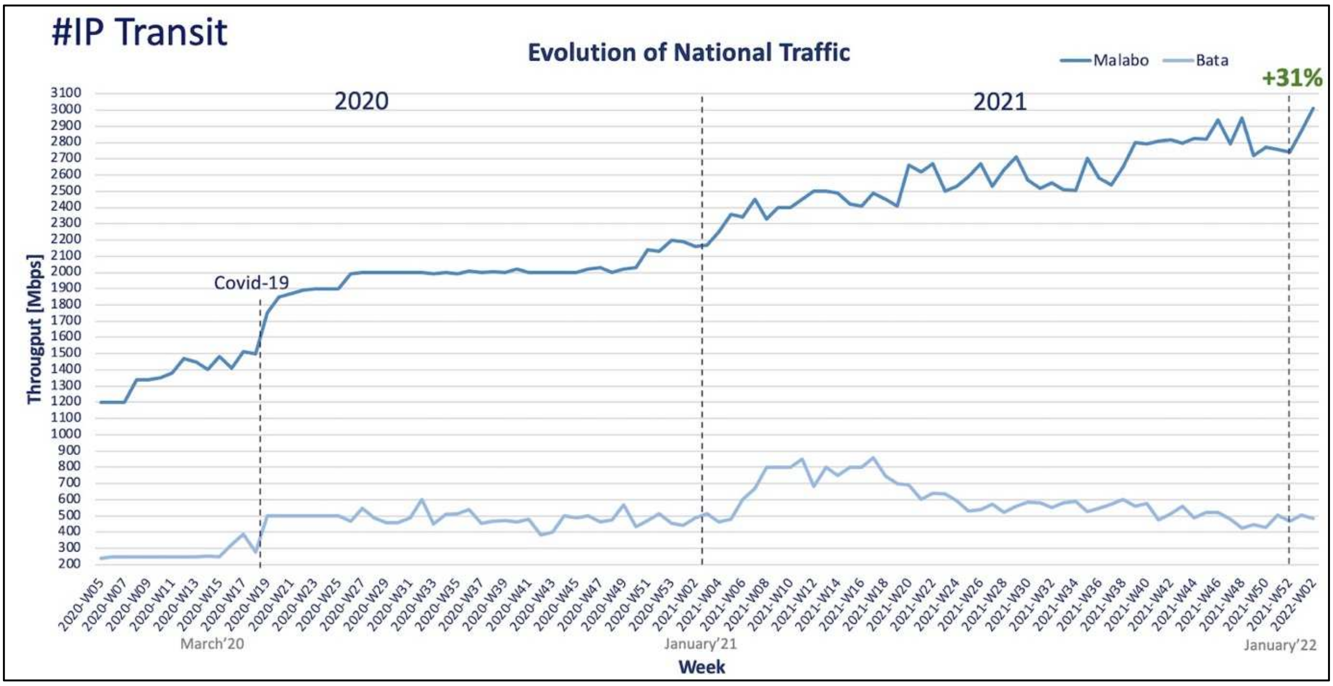

Figure 11. *Traffic Evolution – National Network.*

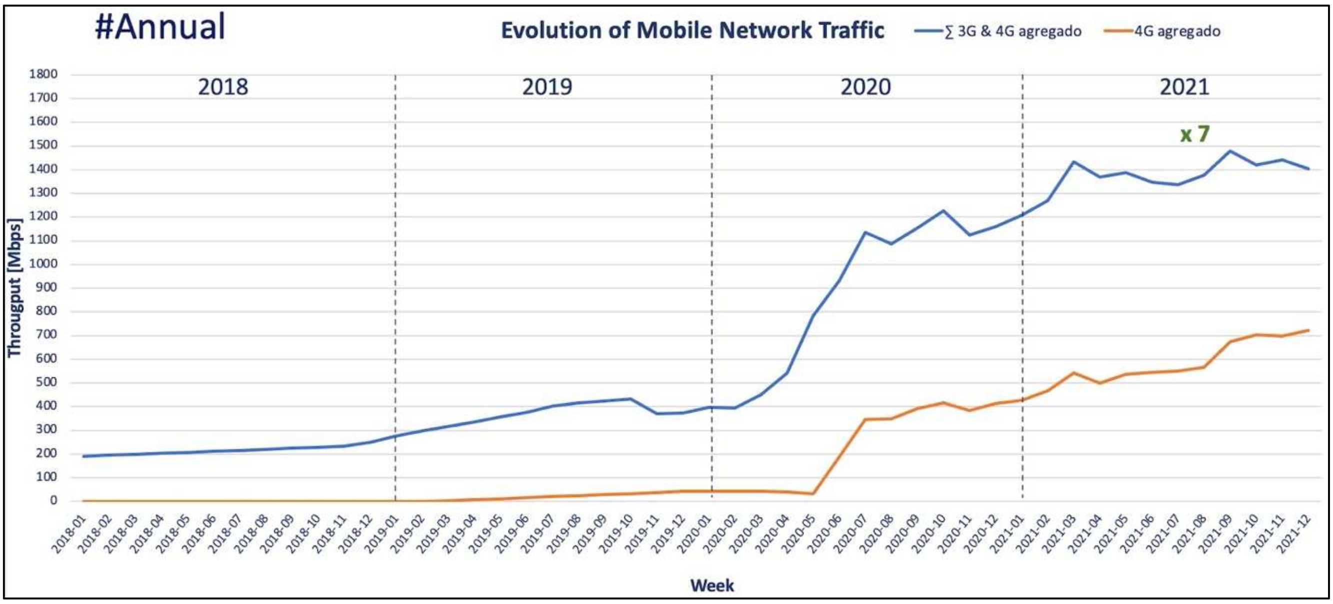

Figure 12. *Traffic Evolution – Mobile Network.*

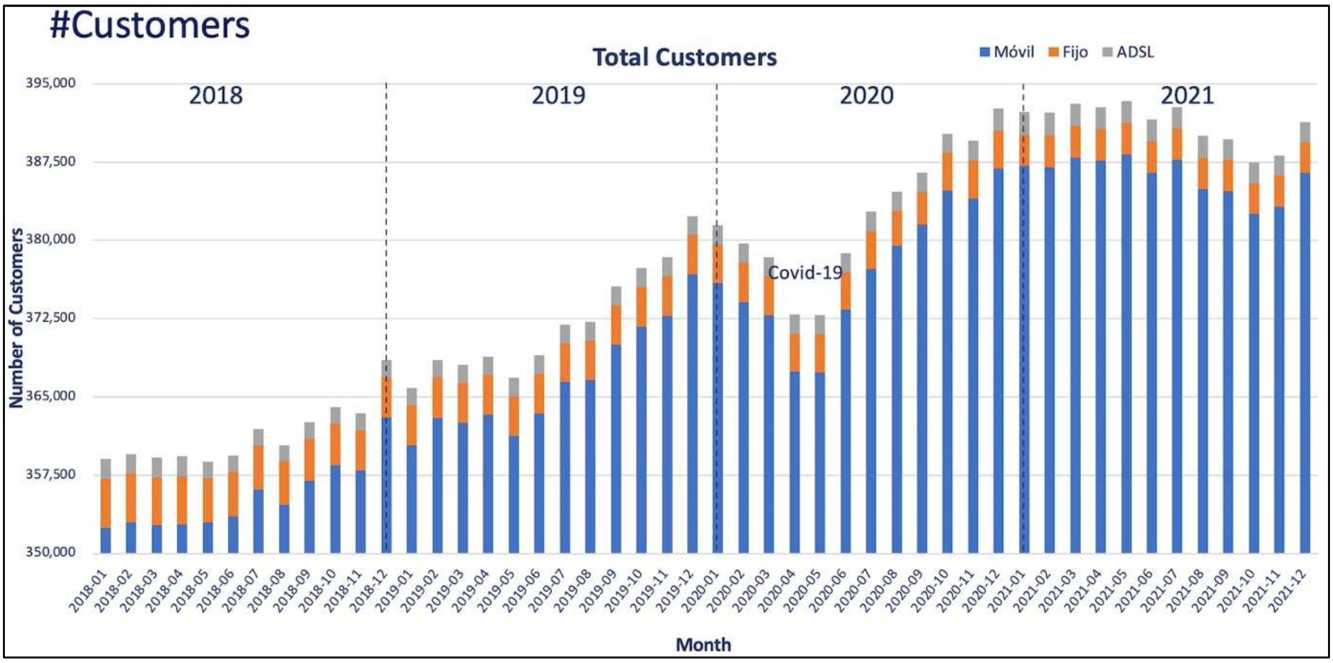

Figure 13. *Total Customer.*

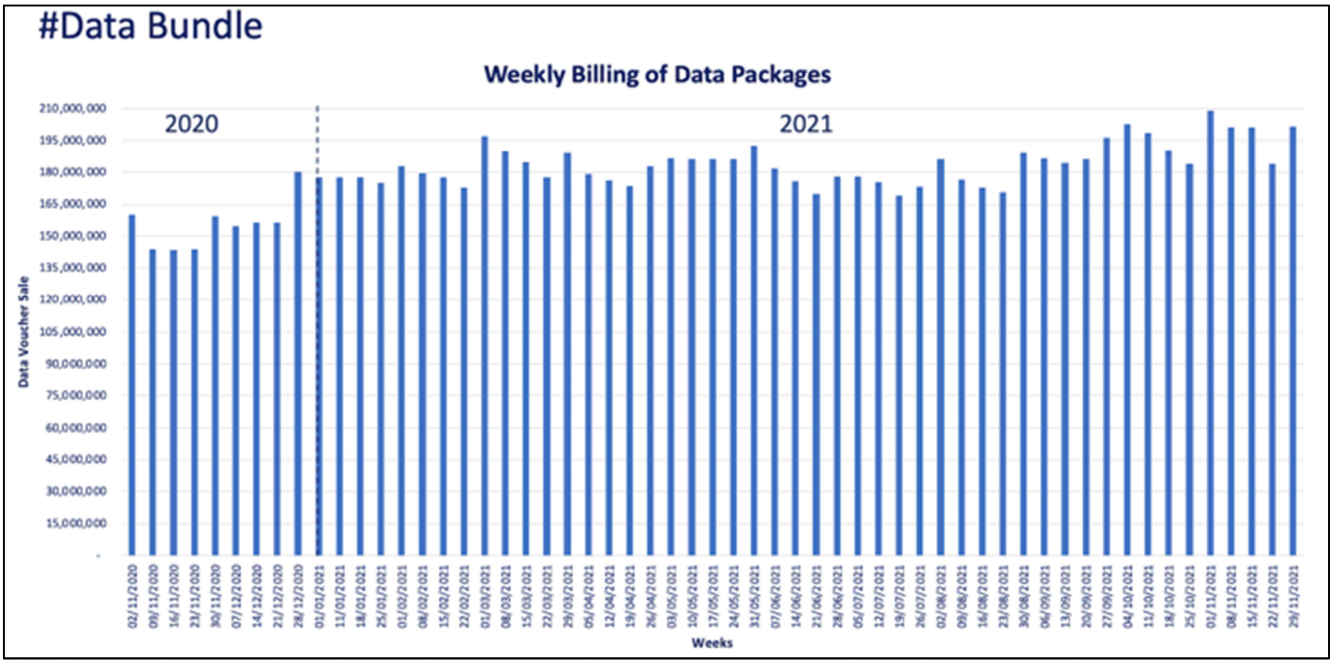

Figure 14. *Evolution of Users.*

6. Conclusion

Considering the challenges GETESA faced in the Equatorial Guinea market, we made the following compelling business propositions, which are delivering outstanding business value to the company.

1) Adopt new generation multi-mode controller, based on the BSC6910 platform, which will support GSM and UMTS co-deployment, thus, simplifying the network topology.
2) Provide a Multi-mode base station with Software Defined Radio (SDR) RF modules in order to allow flexible deployment of new RAT technologies in the future and shorten the time to market.
3) Use distributed Base station in order to improve the coverage and reduce the system power consumption compared to the traditional Macro Base stations.
4) Implement All-IP Radio access network.
5) Reuse existing nodes such as CS&PS nodes, SDM, and Core routers to reduce GETESA's investment.

It is important to mention here that this modernization of the project was delayed due to COVID, which brought with it many technological, logistical and other challenges [16]. The

Swap from 2G to 3G is at 89% with 134 modernized base stations while the Roll-Out of 4G is at 94% with 87 LTE base stations implemented.

While the modernisation project has transformed GETESA to be a more effective and profitable company, there are still some other nontechnical changes that need attention such as, the bureaucratic processes that have been established, these affect the efficiency of the company in: innovating, releasing new products, carrying out the maintenance on-time and workflow issues. The sooner these bureaucratic processes are addressed, the sooner the company will maximise it potential both nationally and internationally.

List of Acronyms

BCF: Base Station Control Function
BICC: Bearer Independent Call Control
BRI: Basic Rate Interface
BTS: Base Transceiver Station
CN: Customer Network
CS: Circuit Switching
CSFB: Circuit Switched Fallback
DSL: Digital Subscriber Line
EDGE: Enhanced Data Rates for GSM Evolution
eNACC: Network Assisted Cell Change
EPC: Evolved Packet Core
GSM: Global System for Mobile Communication
HD: Hight Definition
HSPA: High Speed Packet Access
I-BCF: Interconnect Border Control Function
ICT: Information Communication Technology
IMS: IP Multimedia Subsystem
IoT: Internet of Things
IP: Internet Protocol Telephony
ISDN: Integrated Services Digital Network
ISUP: Integrated Services Digital Network User Part
IVR: Interactive Voice Response
LAN: Local Area Network
LTE: Long-Term Evolution
MBSC: Multi Band, Multi Standard, Multi Carrier
MGCF: Media Gateway Control Function
MGW: Media Gateway
MSC: Mobile Switching Centre
MSAN: Multiservice Access Node
NE: Network Element
NOC: Network Operational Centre
OCS: Online Charging System
OPEX: Operational Expenditure
OSS.: Operational Support System
PBX: Private Branch Exchange
PCRF: Policy and Changing Rules Function
P-CSCF: Call Session Control Function
PLMN: Public Land Mobile Network
PRI: Primary Rate Interface
PS: Packet Switching
PSTN: Public Switched Telephone Network
RAT: Radio Access Technology
RF: Radio Frequency
RNC: Radio Network Controller
RRU: Remote Radio Unit
RSCP: Received Signal Code Power (RSCP)
RTWP: Receive Total Wideband Power
SBC: Session Border Controller
SCP: Service Control Point
SDR: Software Defined Radio
SIP: Session Initiation Protocol
RAN: Radio Access Network
RF: Radio Frequency
RNC: Radio Network Controller
SRVCC: Single Radio Voice Call Continuity
SS: Service Switching
TCO: Total Cost of Ownership
TCP: Transmission Control Protocol
TDM: Time Division Multiplexing
UBBP: Universal Baseband Processing
UMTS: Universal Mobile Telecommunication Services
UMPT: Universal Main Processing and Transmission
VOBB: Voice Over Broadband
VOIP: Voice Over Internet Protocol

Acknowledgements

Not applicable.

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