Broadband Internet access for rural Africa: finding a viable model

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***Abstract*—**While cellular communications have grown exponentially in Africa over the last 10 years, many parts of rural Africa still lack access to broadband Internet services. The question is posed whether this market can be serviced on a financially viable basis using existing broadband technology. To answer this question and determine how this can be done most effectively require an in-depth understanding of the interplay between market, product, technology and financial issues. This paper describes an interlinked model that allows simulation of the relationships between the critical set of market, product, technology and financial variables impacting of the delivery of broadband service to rural Africa. It motivates the use of satellite communications as the most suitable alternative for this market, and continues to identify and compare the available satellite platforms that can be used as basis for broadband access to rural areas. Based on current communication costs and available data rates, as well as typical needs from Internet users, a satellite based broadband service offering is defined that would be cost-effective within the African context. It is then shown that an innovative billing model would be critical to the successful launching of such a service, as has been the case with cellular telephony service offerings in Africa. The paper concludes by presenting a business case for the deployment of satellite based broadband services in order to assist rural Africa in becoming part of the mainstream global economy.

***Keywords*—** billing models, broadband Internet, digital divide, rural Africa, satellite communications.

I. Introduction

Africa's rapid adoption of the mobile phone is quickly closing the digital divide between developed and developing nations for voice services. Rural Africa has however been largely left behind in the shift to ubiquitous broadband Internet, partly because existing telecommunications infrastructure is overburdened by the need for voice services, and partly because those services barely cover urban areas. There are two reasons why the subscriber growth rate of broadband connectivity in Sub-Saharan Africa is so low: prices are very high and availability is limited. The average retail price for basic broadband in Sub-Saharan Africa in 2010 was US$190 per month, compared with US$6 -US$44 per month in India. Typical prices for entry level broadband services in Europe average around US$40 per month, falling as low as US$12 per month in some European countries [1]. Fundamental to the efforts to close this aspect of the "digital divide" is the need to provide a ubiquitous access network that will enable distribution of broadband services to anywhere and anytime throughout Africa on a basis that can be afforded by the rural market. This is a very relevant issue, given the importance of Internet access to function as part of the global economy [2].

To the best of the authors' knowledge no academic study has however been conducted to determine if a broadband service to rural Africa will be a viable operation without the need of cross-subsidization from more established services offered to urban markets. The next obvious research question to address is which existing technology platform to be used to provide such a service most effectively (with ADLS, GSM and satellite the most likely candidates). Should this question be answered satisfactorily one would be lead to address more detailed issues, e.g. how a billing model should be constructed to successfully launch a broadband service in a market with limited affordability.

Against the above background this paper firstly investigates the availability, affordability and market penetration of current broadband services in Africa. We assess the limitations and constraints of currently available ADSL and mobile 3G broadband technologies to determine if these technologies will be able to meet future demands for consumer broadband services in Africa. We then analyze current satellite television broadcast solutions and the synergies thereof with possible consumer broadband services. The technology study furthermore quantifies the potential advantages of using satellite technology to implement a mass consumer broadband service in Africa, based on the ubiquitous nature and rapid deployment capabilities of satellite access networks.

While satellite networks can technically reach all corners of the globe the issue still remains whether the commercialization of a satellite based broadband service for the mass consumer market will prove to be viable in Africa. The difficulty in answering this question lies in the fact that market size, revenue per customer, cost of service delivery, design of the product-service offering, required data delivery capacity and network architectural design are all interlinked – none of these important factors to assess the viability of a broadband internet service to rural Africa can be quantified in isolation.

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To illustrate this dilemma: it is widely accepted that the size of any market is dependent on the relationship between price and perceived value, i.e. by the way the product-service combination is packaged. The rate of adoption of a new technology concept is furthermore impacted by the associated billing model - the success of the mobile telephony prepay model and of pay-TV subscription services have demonstrated that the business model for the commercialization of technology solutions is critical to ensure mass adoption. Offering optimally packaged broadband services however requires specific minimum volumes of scale, and this critical mass differs between different technology platforms. Optimal pricing of the offering will have to strike a balance between the conflicting objectives of maximizing market update and maximizing cost recovery per customer. The billing model will furthermore influence not only the rate of market uptake but also the balance between upfront investment and downstream cost recovery – in the case of cellular telephony in Africa the operators largely subsidized handsets in order to accelerate market adoption, which required substantial upfront investments but proved to be very successful as market uptake exploded beyond all initial expectations.

The question is whether a similar approach will prove to be viable for broadband Internet, and if yes, what the most appropriate strategy would be to unlock this latent market potential while controlling financial risk to the service provider under conditions of uncertainty in untested markets.

This paper addresses the above problem by designing an interlinked simulation model that includes the complete set of relationships between those variables that significantly impact a business operation providing broadband services to the currently under-serviced market in Africa. In order to evaluate various alternatives regarding price, product definition and selected target market an accurate mathematical model is developed to simulate the various business outcomes as function of a set of input parameters. Using this model it is demonstrated that different decision-making options can be compared on a quantified basis through scenario analysis, in the process quantifying not only expected market uptake for specific service offerings but also assessing the impact of technology platform selections in terms of revenues, profits and required financial investments.

The paper is structured as follows: In section II we develop a model to quantify the under-serviced market in Africa for broadband Internet access as function of price and structuring of the service offering. Historic data on related technology markets in Africa, including the adoption rates for PCs, ADSL, mobile telephony and pay-TV is combined with a price elasticity of demand model to produce an estimate of the expected market size for different scenarios.

Section III provides an overview of existing broadband offerings and compares competing technology platforms in terms of functionality and cost. We then motivate the use of satellite communications as the most suitable alternative for this market, and proceed to identify and compare the available satellite platforms that can be used as basis for broadband access to rural areas.

In section IV a satellite based broadband service offering is defined that will be cost-effective within the African context, based on current communication costs and available data rates, as well as typical needs from Internet users. Section V describes the most appropriate design of the technology platform to find an optimal balance between the expected needs of the market in terms of data capacity, the delivery capability of the satellite transponders and the resulting upward and downward link rates.

In section VI we investigate the possibilities for billing model innovation by defining a new billing structure for broadband services that provides end-users with the capability to adapt their broadband usage patterns to meet their budget constraints. It is shown that this approach has the potential to set a completely new paradigm for users regarding their ability to influence the cost of the service, which has proven to be critical to the success of mobile telephony in Africa.

In section VII a scenario analysis is performed to illustrate how the integrated business model can support decision making against different sets of input data. We investigate the interaction between technology options and other factors that will impact on a successful business strategy for satellite based broadband access, including market risk and funding requirements.

The paper concludes by presenting a business case for the deployment of satellite based broadband services in rural Africa. We highlight the critical technology factors that differentiate the various broadband options for rural Africa, as well as the business issues that will impact on the eventual successful deployment of such services in order to assist rural Africa in becoming part of the mainstream global economy.

II. Quantification of the under-serviced market for broadband Internet access in Africa

The first issue to address is whether a significant under-serviced market really exists for broadband Internet services in Africa1. This was investigated at different levels in a recent study [3], and only the main findings will be reported in this paper.

While some progress has been made at institutional level, only a few African countries have a modern institutional framework that governs the regulatory aspects of the telecommunication sector [3]. As a result the majority of African countries still only have a partially deregulated market. The private sector has proved to be willing to invest significantly into mainly cellular communications infrastructure, resulting in a 10 fold increase in the number of cellular subscribers in the last 5 years [4].

The average Africa Internet access market penetration is still only 6.7% against a world average of 24.9% [5]. What is however of particular importance is the fact that Africa currently has the fastest growing telecommunications market:

- Internet users in Africa are growing at an annual rate of 30.6% compared to the World average of 17.0% [6].
- Mobile cellular subscriptions in Africa grew by 47%, compared with the average world growth of 23% [7].

These statistics provides an indication of the demand, affordability, growth and potential of providing telecommunication services to the emerging Africa market. Market reports [8] show that, in all of the countries included in the studies, market demand is increasing and the demand for Internet in Africa will exceed supply. The forecasted total number of PC connections for Africa is 20 million by 2014. Technologies that provide the most effective communication coverage to the continent will be the best positioned to leverage this pan-Africa demand.

In [3] the estimated under-serviced market in rural Africa is quantified through the following approach: Firstly the current figures for penetration of Internet in urban areas as well as the average cost of Internet service offerings were extracted from market research studies. The relative size of urban versus rural populations, as well as the distribution of the urban and rural populations amongst so-called Living Standard Measure or LSM categories were then determined from historic references [9]. By combining these statistics with a price elasticity-of-demand model [3] the expected size of the rural market in 16 target countries was estimated for different pricing levels of a broadband service. This analysis produced a figure of between 10 and 12 million end-users that will be able to afford such a service at typical broadband rates but who currently cannot access any of the existing services [3]. In subsequent sections these figures for estimated under-serviced market size will be combined with results from the technology and product-service offering studies to assess the viability of offering a commercial broadband service.

III. Comparison of Technology Platforms

The key to unlock the consumer broadband Internet market in Africa lies in the ability to meet the following principal requirements:

- The need for ubiquitous service coverage;
- the need for affordable end-user equipment and implementation; and
- the need for affordable monthly service charges.

The question is: can these requirements be effectively met for the currently under-serviced market, and if yes, by which technology platform?

In this paper we compare three alternative broadband access technologies: ADSL, mobile (cellular) and satellite. As the latter option for Internet access is less known compared to ADSL and cellular, a brief description of satellite Internet architectures will first be provided.

Direct-to-Home-Internet (DTHi) access services is defined as Internet access services that are provided to the consumer market using satellite broadcast technologies [10]. The DTHi service solution broadcasts directly to the home consumer, as shown in figure 1 below.

The DTHi solution architecture incorporates the following key elements:

- *Uplink Station*

The central satellite uplink station provides the gateway and interface between the terrestrial Internet network and the satellite communication network. The uplink station is typically located close to a first tier Internet backbone network and integrates the IP access network with the satellite transmission network.

- *Satellite Distribution Channels*

The satellite distribution channel forms the signal transmission medium between the uplink station and the customer terminal equipment. For Internet access services this is a two-way communication channel interconnecting the Internet with the consumer.

- *Consumer Terminal Equipment*

The consumer terminal equipment includes an outside antenna, receiver and transmitter unit and an indoor modem unit per each consumer home.

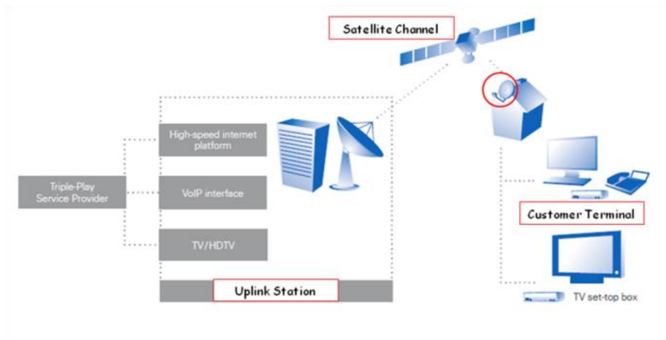

Figure 1 Direct-to-Home Internet (DTHi) network overview

For the purpose of the comparative technology platform analysis the following criteria will be considered:

(1) Geographical Communication Coverage

Key to unlocking the mass consumer market is the capability of the technology to reach the mass consumer market and to do so it must be able to cover wide geographical areas. ADSL services utilises the current copper line networks and the availability and reliability of these in Africa is very limited. GSM Cellular networks have vast coverage throughout Africa, yet even with these large coverage areas it still does not provide coverage to most of rural Africa. Satellite by contrast is the perfect medium to broadcast the Internet to Africa with 100% signal coverage.

(2) Service Price and Affordability

Service affordability is a dominant factor in providing a solution to the emerging mass Africa market. Affordability of a service is determined by the nominal costs of the service as well as the product pricing structure. Considering the mobile telephony market in Africa, the nominal cost of a call is $0.20 per minute, which is fair value and not very cheap, while the top-up vouchers are available as from $5. The affordability to the market is therefore a function of both the call rates as well as the minimum top-up rate. Pricing for a 1Mbps, 5GByte ADSL service in South Africa averages $100 per month.

Currently mobile networks offer attractive pricing for data services at around $20 per month. The capability of mobile networks to meet future growth and still maintain profitability is however questioned by various industry analysts [11]. The single source nature of satellite Internet broadcast signals has the result that no income multiplication can be done, as for TV broadcasts, and hence the pricing is for the higher income market.

(3) Implementation Costs and Requirements

Initial purchasing cost, which includes equipment cost plus any implementation costs, is a major factor and must be kept to a minimum. The large scale deployment of additional copper cable networks for ADSL in Africa is not feasible, partly as a result of high levels of copper theft. In high density areas operators implement fibre networks to business and high-end consumer markets. Mobile broadband networks require continuous upgrading to base stations and back haul networks to deal with traffic volume increases. This is both time and capital intensive. For satellite the network cost required to provide services over the continent is limited to the upgrading of a single earth station and contracting of the applicable satellite capacity.

(4) Access Speed

The technology solution must be able to meet the current broadband access speeds as well as to increase to higher levels expected to be required in future. ADSL services are well positioned to deliver broadband services at access speeds of up to 4Mbps. Access speed on Mobile broadband networks greatly depends on the range and overall network congestion. Realistically, the average transfer rate will vary from 1 to 2 Mbps depending on the quality of the signal and the number of connected users. All satellite terminals can be configured for maximum network speed which can be 4Mbps or higher.

(5) Quality of Service Requirements

The primary purpose of the proposed solution is to provide broadband Internet access services to the consumer and small office market. This will be reviewed in terms of service access speeds, network performance and expected user experience. ADSL services differentiate strongly between local and international content with the associated user implications. Mobile networks have well developed tools to meet QoS requirement. For satellite all the required quality of services can be integrated into the hub network.

(6) Data usage volumes

As it is expected that the use of broadband services will grow exponentially, broadband technologies must be able to scale up in order to deliver ever increasing data volumes. With fibre networks forming the core of most ADSL networks they are well positioned to deal with data traffic demand increases. Mobile networks are however expected to become more and more congested as smartphone users demand more data at higher speeds. The wideband nature of satellite signal carriers of typically 72MHz can deliver up to 140Mbps per channel which can readily meet higher user traffic demands

(7) Network loading and congestion

The ability of broadband networks to provide acceptable levels of service during peak customer demand periods is critical. ADSL terrestrial networks with integrated fibre core networks can provide the best possible network resilience against peak traffic demands. Due to the cost implications and limited available operating frequencies mobile networks can not readily be upgraded and network congestion is often experienced. Broadband satellite networks are a single point resource with limited options for traffic loading management.

(8) Billing Requirements

A technology solution for the mass consumer market must be able to meet the billing requirements of the consumer market in terms of flexibility and the option to select incrementally increased service offerings. Public operators offering ADSL traditionally do not engage in usage billing models and still offer broadband access at a fixed rate per month linked to a maximum amount of data usage allowed per month. Globally mobile operators are currently offering usage based services and other advanced packages. Current satellite operators typically offer fixed rate packages linked to contended services. It is expected that a "usage-base" model will deliver better user experiences.

(9) Net neutrality

Service providers today have the ability to control the content of broadband access services to give lower or higher priority to some types of content such as voice traffic or video download data. The manner in which service providers apply discretionary rules to the broadband content refers to the issue of net neutrality. The primary income of public operators offering ADSL is still voice based services and hence there is a tendency to degrade the quality of service of Skype and other VoIP data services that compete with analogue voice communications. The primary income source for mobile network operators is also voice-based services and thus they are similarly inclined to provide Skype and other VoIP services with a lower priority and poorer quality of service. Satellite operators have no legacy voice business interests to protect and can ensure 100% net neutrality.

(10) Availability

Access and availability of the product to the consumer public is a critical element that will determine the viability of the service. While ADSL is in the best position to handle increasing data volumes where it is available, the simple fact is that ADSL is unlikely to be an available option for the bulk of Africa’s rural population for several decades to come. Mobile Internet is available over a more extensive range, but where it is deployed the tendency is for voice communications to use the bulk of available capacity. It would therefore seem that, although it is currently still the most expensive option, satellite may in fact be the only option for a significant portion of the African population for the foreseeable future.

The above comparison confirms the following:

- that ADSL services are the most suitable and appropriate technology to provide consumer broadband services where landline infrastructure is available;

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- that due to the lack of availability and implementation requirements ADSL services are not a feasible as an option to service the complete Africa mass consumer market;
- that, in the absence of ADSL as alternative, mobile broadband services is the next option to consider for meeting consumer demand for broadband access services;
- that mobile broadband services have inherent bandwidth and cost of infrastructure limitations that will result in this technology option not being able to meet the expected future demand in Africa; and
- that satellite technology, while still being too expensive for the lower income categories, is the only remaining viable alternative to meet the demands of the currently under-serviced broadband market in Africa.

IV. Definition of an Affordable Product Service Offering

In the previous section we established the fact that for a large portion of the African population satellite is currently the only viable alternative for broadband Internet access, even though it may not be an ideal option taking into account cost considerations. The next challenge is to define a product service offering that can be supported by currently available technology and that will prove to be affordable to a sufficient portion of the target market to make such a service viable in the short to medium term.

Currently there are already 71 satellites with at least partial coverage over Africa, operating approximately 2,794 transponders providing substantial communication capacity for this market. A recent study showed that these transponders are running at between 60 and 99 % of full capacity, providing proof that even without an optimally packaged broadband service there is already significant demand from Africa for satellite based services [12].

A further selection to make is the type of satellite band to use, with a choice between C-band (3.7-4.2 GHz), Ku-band (11.7-12.7 GHz) or Ka-band (26.5-40 GHz). The optimal choice is dictated by the expected subscriber density: while Ku-band transponders cover a significant portion of a continent, with data rate capacity of around 1-2 Gbps, Ka-band transponders cover only a relatively small area (typically one large metropolitan area) while offering data rate capacity of around 45 Gbps. Ka-band will thus be the technology of choice for geographies with very high subscriber densities (typically as would be the case for South-East Asia or the coastlines of the USA), while Ku-band will be the optimal choice for the much lower expected densities in rural Africa.

Assuming a minimum monthly fee of around $100, the proposed service will be targeted primarily at more affluent individuals and small to medium sized business. Based on a recent study [13] the needs of the small business of the future, including video-conferencing and third-party hosted applications, will require at least a combination of 1Mbps downlink and 256 kbps uplink at the lower end, going up to a combination of 15 Mbps and 2 Mbps respectively.

In the case of consumer clients the dominant driver of data consumption for Internet traffic is real-time entertainment with social networking in the second place [13]. Within these categories streaming applications that rely on peer-to-peer architectures (sometimes called "peer-casting") have achieved worldwide market penetration.

Regarding data usage, the current offerings of mobile service providers indicate that typical requirements range from 1Gbyte to 5 Gbyte per subscriber per month.

A major challenge in all Internet markets is the fact that usage tend to be very dependent on time-of-day, as shown in figure 2 below, with real-time entertainment causing a significant peak in data consumption during the period 6pm to 9pm.

In summary, the type of broadband service to be incorporated into the simulation model will be based on the selection of the most suitable Ku-band satellite, offering a combination of down- and uplinks starting at 1 Mbps and 256 kbps, combined with total monthly data usage of at least 1 Gbyte, and with the option to offer time-of-use based pricing in order to help manage peaks in demand.

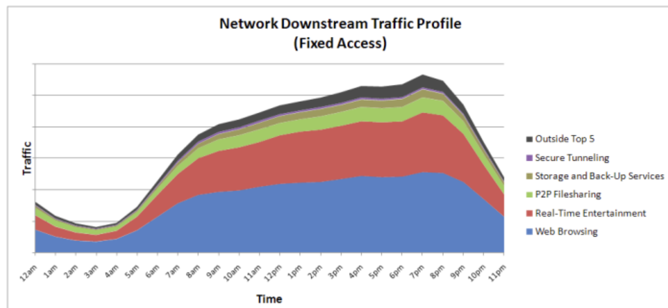

Figure 2 Typical Network Downstream Traffic Profile for European Network [13]

V. Technology Network Design

Selection of the most suitable equipment for implementation of the satellite broadband network is a complex trade-off between upfront capital outlay, the influence of the consumer equipment cost on the rate of market adoption as well as the minimum cost of the satellite data transmission channel. Higher cost terminal equipment offers more efficient data communication and increase the barrier to entry yet lowers the rate of market adoption.

The most critical parameters when selecting between equipment alternatives include the cost of hub equipment (which will increase initial capital outlay and hence increase upfront risk and time to breakeven) and cost of terminal equipment (which will increase customer capital outlay and therefore influence rate of market adoption and thus increase the funding required to sustain the operation until break-even is achieved). The date rates that the satellite can handle for both the downlink and the uplink, and how this compares with aggregated customer demand, will determine the number of customers that can be accommodated per transponder as well as the quality of Internet experience that will be offered.

In order to determine which of several available satellite platforms will be the optimal choice for a broadband service into Africa a simulated study was performed which is described in detail in [3]; only a summary of the approach that was followed and the results obtained are given in this paper. One of the critical elements of this simulation is the so-called link budget, which matches the satellite transponder capacity in both directions with the aggregated needs of Internet customers, allowing the estimation of the maximum number of customers that can be serviced by one transponder. A satellite channel signal transmission link power analyses, also referred to as a link power budget, was hence completed to determine the most suited communication channel carrier specifications, the channel reliability and resource efficiency.

The carrier analysis was done in the forward direction, i.e. from the hub to the remote sites, and in the return direction, i.e. from the remote sites to the hub. The results of the link budget analysis were used as basis for comparing several alternative satellite options.

The forward link carrier results were based on a 36MHz DVB-S2 carrier on a saturated 36MHz transponder. The customer platform incorporates ACM (adaptive coding and modulation) on the forward link which ensures that the highest efficiencies are achieved for remote sites in all geographical locations in the footprint and during all weather conditions.

Similarly a carrier multiple distribution analysis was done for each of four different return link carrier types from a remote site 1m antenna to a 5.6m hub antenna located in Johannesburg, South-Africa. All return carriers use 4CPM (constant phase modulation) which is a non-linear modulation type and yield an efficiency of between 55% and 71%..

The above approach with the described set of assumptions was used to simulate a typical business operation offering such a service to the African continent. The results of the simulation in terms of utilization of available capacity, number of customers that can be accommodated and resulting business performance are summarized in the table below:

Table 1 Review of alternative satellite equipment options

Satellite Characteristics Analyses	New Dawn	Amos5
Time to market	3 months	9 months
Addressable market	Sub-Sahara Africa	Southern Africa
Terminal sales growth rate required to turn-around the business with available funding	150%	200%
Equipment Characteristic Analyses	Newtec	Gilat
Hub capex equipment	$750,000	$450,000
Remote terminal equipment	$450	$650
Equipment implementation cost	$80	$160
Inbound carrier utilization	182%	93%
Effective 4/Mbps inbound service cost	$5,356	$2,732
Maximum funding required	$1,507,572	$2,352,870
Time to cash positive	6 months	18 months
Number of consumers per transponder, year 1	2632	1154

The significant difference in time to positive cash flow results from the higher remote terminal equipment cost for the 2nd option, resulting in slower expected market adoption rates.

The simulation demonstrated that the choice between different available satellite platforms, that on paper appear to offer rather similar functionality, can make the difference between a time to positive cash flow of either 6 or 18 months[3]. In practice this can effectively be the difference between success and failure for the underlying business operation.

VI. The Role of Billing Models

A good billing model will enable fast market adoption by striking an optimal balance between the value offered to customers and the cost to deliver that value. To provide a sustainable and profitable Internet access service, two opposing forces within the network architecture must be balanced: charging rates and policy.

The role of charging rates is to maximize revenue. Policy's job is to reduce network costs by managing bandwidth. In broadband data networks, the trigger for action is either an abundance or lack of bandwidth for a particular user, application or portion of the network. An advanced charging and control system reacts in real-time to bandwidth availability, being able to either reduce or increase bandwidth for particular users as directed by policy.

Problems occur when one of these factors has too much weight. When emphasis is on low charging rates revenues will grow, but the network will need to support too many users, degrading QoS and the customer experience. When quality policy is over-emphasized, high QoS is offered, but revenue suffers and the operator earns a poor return on its network investment.

The satellite broadband access network has some very specific performance characteristics that must be considered when defining the most suited billing model. These relate to the costing and data rate parameters of the outbound and inbound channels.

- *Outbound Channel:* The outbound channel (from the hub to the remotes) is a single saturated high powered DVB-S2 carrier operating at 70Mbps through a 36MHz channel. The channel transmission efficiency for different modulation codec options is detailed in table 2 and has an average efficiency of 1.94bits/Hz. The outbound channel is considered very efficient and offers up to 99Mbps using a 36MHz RF channel thus translating into a lower cost per bit for delivery of user data than the inbound channel.
- *Inbound Channel:* The inbound channel (from the remote to the hub) is operating from the smaller (1m) antenna system and lower powered (800mW) terminals and is thus limited in the possible communication channel efficiencies. The communication channel modulation types and efficiencies that can be supported by the network provide an average efficiency of 63%. The efficiency range from 0.55bits/Hz to 0.71bits/Hz which is inefficient compared to the outbound channel and will lead to higher cost per bit levels.
- *Inbound Power Limitation:* The inbound communication channels that provide communication from the small 1m, 800mW remote terminal to the hub is power limited and

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constrained to a maximum data transmission rate of 256kbps. The network architecture will be designed to provide multiple of in-route channels as is required to provide the total transmission capacity for the return link communication.

- *Billing influence of network transmission:* The combined effects of the channel efficiencies and the return link power limitation is that the network will deliver outbound data services from the hub to the remote more cost effectively than the inbound channels. The net effect is that the billing model should be able to differentiate between the outbound and inbound data flows and apply different costing structures to the respective data paths.

The eventual billing model that is used should reflect at least the following factors that contribute towards the cost of providing the service:

- Access speed;
- Monthly data usage;
- Time-of-day of usage;
- Type of data.

For the simulation studies the following weightings were used to convert the different factors into one monthly fee (assuming a standard downlink access speed of 2Mbps):

Table 2 Price weighting factors for usage based billing

Gbytes	**Wght**	**Time of Day**	**Wght**	**Type of Data**	**Wght**
0	1.0	05h - 8h	1	email	1.2
1	0.9	08h - 18h	1.5	Browsing	0.9
2	0.8	18h - 22h	0.8	Social media	1.4
4	0.6	22 - 01h	0.5	Downloads	0.9
10	0.5	01h - 05h	0.3	Games	2.0

In order to assess the applicability of the model it was applied to three typical end-user scenarios and the expected monthly costs were calculated:

Base service: The base service applies to all subscribers and is a monthly subscription fee that includes 1Gbyte of data at a fixed rate of $75 per subscriber per month.

Business User: The business user profile has a usage of 2GByte of additional data for mostly email traffic between the hours of 8h00 to 18h00. The pricing factor for the top-up services is 1.4 with a rate of $144.

Socialite: For the socialite using 3GByyte of additional Facebook and other social media applications data between 18h00 and 22h00 the total pricing factor is 0.7 resulting in a rate of $101.

This costing model was tested against a selected group of ISPs operating within different African countries, and in general the feedback was favorable, indicating that this model will allow customers to effectively match the cost of the service with the value that is delivered.

VII. Scenario Analysis

A quantitative business model was developed in Excel for typical business scenarios faced by a business operation providing satellite broadband services into Africa. This included the modelling of the important business relationships as well as the quantification of the respective input parameters. Once the model was constructed, the second step was to apply the model to provide output data for different business decisions and options that had to be considered. In particular the model was applied to support and validate decisions regarding the following business considerations:

1) Selection of the most suited satellite scenario in terms of availability and cost: The inputs used for this analysis were satellite supply terms, teleport uplink terms, cost for hub platform and operation, link budget analysis and implementation costs.
2) Evaluation of the impact of different remote terminal equipment types (consumer or professional version): inputs include terminal equipment and implementation costs and network hub equipment cost.
3) Simulation of different pricing and billing models: usage based billing based on the input data in table 2 above was compared against fixed rate billing.

For each of the above options the projected risks and returns were quantified in terms of sales revenue potential, time to positive cash flow, expected profit over 5 years and required financial investment. To make the scenario analysis more representative for uncertain market conditions, it was repeated for both a conservative and an aggressive market scenario, allowing market share after 5 years to range from 8% to 25%.

A summary of the findings is provided in Table 3 below; in [3] the outcome of this scenario analysis is described in more detail.

Table 3 Summarized outcome of scenario analysis

Scenario	**Option 1**	**Option 2**
<u>Satellite Selection:</u>	<u>New Dawn</u>	<u>Amos 5</u>
Time to market:	3 months	9 months
Sales rate required:	150%	200%
Subscribers yr1:	3223	1500
Addressable market:	Sub-Sahara Africa	Southern Africa
<u>Equipment Selection:</u>	<u>Consumer.</u>	<u>Professional</u>
Max funding:	$1.4M	$2.1M
Months to cash positive:	6 months	15 months
Market penetration:	Nominal	Less 48%
<u>Billing Model Selection:</u>	<u>Usage billing</u>	<u>Fixed billing</u>
5yr Return:	$32M	$16M
Yr1 Subscribers:	2632	1418

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The scenario analysis firstly provides proof that a satellite platform can be used to provide broadband services into Africa at monthly rates that will attract a sufficiently large market to make such a service a viable operation, without having to subsidize such an operation from the returns generated in more established markets (as is most likely the case for most satellite based services currently offered into Africa).

Secondly it can be stated that a usage-based billing model not only provides a more affordable option to the market but also yields better financial results. Even assuming the same number of subscribers (which could possibly be higher for usage based billing given the increased flexibility offered to customers) overall revenues and profits are higher for usage based billing, resulting in a more attractive return on investment and NPV (net present value).

The consumer version of end-user terminal equipment is expected to provide more attractive results compared to the professional version, mostly due to lower upfront cost to end-users that will results in faster market adoption.

As far as the satellite platform selection is concerned the New-Dawn satellite operated by Newtec produced the most favourable results, as its combination of up- and downlink data rates, combined with supply terms, better matches expected market demand for data capacity compared to those of competing platforms.

VIII. Summary and Conclusions

This research work adds knowledge and insight to the field of applied business strategy as applicable to providing advanced technology-based services for emerging markets. The research work is specifically focused on the case for providing broadband services into rural Africa and proposes a new billing model for satellite based broadband services.

The research work conducted clearly identified that there is a significant under-serviced market sector in Africa and that the demand for broadband services is growing. It furthermore showed that very limited ADSL infrastructure is available throughout Africa and that the available infrastructure is not meeting the demand. While mobile 3G services are currently the most effective option to provide broadband services, these services have two principal constraints. Firstly the network communication coverage area is not ubiquitous and large service-gaps exist and secondly the technology has some fundamental capacity limitations that prevent the large scale deployment of data services to the mass market.

The research work clearly demonstrated that satellite technology is very well suited to provide services over a very large geographical area such as rural Africa. The research also found that the point-to-multipoint nature of satellite technology is well suited for the delivery of broadcast services such as Internet access services.

Affordability and availability are the two principle conditions to provide services to the mass consumer market in Africa. The research proposes a new usage-based billing model to offer broadband services to the under-serviced market in an affordable manner. Integrating the proposed billing model with satellite technology will enable the creation of a broadband service that will be available throughout Africa, that will be affordable to the institutional, small business and higher end consumer markets, and that can be operated on a financially viable basis. The integration of satellite technology with the usage-based billing model therefore offers a new alternative for the mass broadband market in Africa.

In order to verify and validate the results of this study the different factors and inter-relationships for the operations of a broadband service provider were integrated into a quantified business model. The business model was used to analyze various business scenarios, considering different options during the business strategy definition process. Using this quantified model it was possible to recommend the most optimal set of business decision options, taking into account the impact of all of the major factors impacting such a business.

Future work in this field will involve the testing of the model that was presented here in practical conditions. The research team intends to closely work with commercial operators in this industry to verify whether the simulated results of this study can be achieved in practice, in the proposing validating the research approach that was followed.

In conclusion it can be stated that the provision of broadband services to rural Africa has been theoretically proven to be a viable business proposition, combining existing satellite platforms with a suitable business strategy. It is hoped that the results of this work will make a useful contribution towards closing the remaining digital divide for rural Africa, helping these impoverished areas to participate on a more equal basis in the global economy.

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