Mobile Telecommunications Networks for the 2014 World Cup

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Table of Contents

This paper was commissioned by the GSM Association (GSMA), the world trade association of mobile operators. It analyzes the main challenges for telecommunications companies, and in particular mobile operators, as they prepare for the 2014 World Soccer Cup and the 2016 Rio de Janeiro Olympic Games in Brazil. Decisions can then be made based on the elements presented in this paper, and investments channeled in the right direction.

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Executive Summary

2014 FIFA World Cup Brazil

Hosting the 2014 World Cup represents a historical point for Brazil, opening up a wide range of challenges and opportunities. Large sporting events are a major undertaking, demanding initiative, investment and oversight from the government, various segments of the economy and from society itself. Hefty investments in infrastructure will be needed and companies will face a unique opportunity, not only because of the millions of people from all over the world who will flock to Brazil, but because of the high level of exposure the country will receive.

The scale and dimension of the infrastructure demanded by the Fédération Internationale de Football Association (FIFA) to host the 2014 World Cup games is a real challenge. The enormous influx of people coming to the host cities vastly increases the need for various basic services such as transportation, telecommunications, water distribution, sanitation, electric power distribution, financial services and health care. These systems are interdependent, and an incident in one area can have critical consequences on the others. The concept of critical infrastructure protection, used to identify the critical telecommunications services during the 2007 Pan-American Games in Rio de Janeiro, will be vital for the 2014 World Cup.

Besides the stadiums and surroundings, with their great crowds of people during the games, other World Cup-related festivities and tourist attractions will present mobile phone operators with both opportunities and challenges. Among the most popular of these are the Fan Fests, created by FIFA during the 2006 World Cup in Germany. Fan Fests were set up in 12 different places in Germany, with a total of 18 million people watching the game on giant screens.

Telecommunications Networks in Brazil

The privatization of telecommunications in Brazil took place on July 29, 1998, and today four companies control the mobile sector: Vivo, an association of Telefonica and Portugal Telecom; Claro, controlled by América Móvil; TIM, a subsidiary of Telecom Italia; and Oi, a Brazilian-owned telco. Mobile telephony reached 176.8 million subscribers in February 2010, of which 82.5% were pre-paid and 17.5% post-paid. Approximately 96.6% of the population is serviced by at least one operator, while 64.7% can choose between at least four alternatives. The growth of wireless penetration has largely been driven by the implementation of pre-paid services, providing the less affluent with access to telecommunications services.

In February 2010, over two years after the first third-generation (3G) commercial operations were launched, there were 8.1 million terminals in use, or 4.6% of the market. Anatel – the Brazilian telecommunications regulator – believes that in 2014 the number of mobile accesses lines in Brazil will be over 210 million, representing a mobile teledensity of over 100%, with more than 55 million being mobile broadband subscribers. These projections to 2014 suggest a steep growth, not only in the number of subscribers but also in the resulting spectrum needs and infrastructure investment requirements.

Mobile Technology In 2014

Mobile broadband forecasts indicate that in the coming years, the most widely used technologies in the world will be HSPA/HSPA+ and LTE. HSPA is the first step in the WCDMA evolution, claiming to offer data transmission rates ranging from 1.8 Mbps to 14.4 Mbps, to support bandwidth-hungry applications. LTE introduces new radio communications technology with even greater spectral efficiency, offering from two to four times more capacity than HSPA systems.

Several commercially tested digital TV technologies are currently available and will likely become mainstream technology worldwide by 2014. After a series of risk analysis studies and standard adaptations for country-specific characteristics, Brazil chose Integrated Services Digital Broadcasting – Terrestrial (ISDB-T) in 2006. Designed from the ground up for mobile and portable reception, ISDB-T transmits HDTV programming and mobile TV within in the same frequency channel, which is a plus compared to other digital TV standards that need additional spectrum for mobile transmissions.

Brazilians' passion for TV, along with the widespread adoption of cell phone technology, is a factor that boosts the country's great potential for mobile TV. In fact, research shows that the mobile handset and the TV set are the two most important items in the average Brazilian's everyday routine (while computers with Internet access rank only in third place).

SERVICES IN 2014

From the point of view of user acceptance of services, and consequently generated revenue, the vast majority of mobile users in the world, and in Brazil too, use their mobile phones mainly for voice communications. Next come SMS (or Short Messaging Service) messages, and finally data services.

A gradual increase in data service access is expected through 2014. Besides traditional voice and SMS traffic, there will be an increase in SMS traffic associated with applications and special sales during the event. Mobile Advertising probably will add moderate traffic over SMS and MMS (or Multimedia Messaging Service), according to advertising business models. Other data services likely to expand by 2014 with 3G technology are Mobile TV and, most importantly, Mobile Social Networking.

We expect the expansion of Mobile TV in Brazil to concentrate on the free-to-air broadcasting as a result of the adoption of the ISDB-T standard. Despite the adoption of ISDB-T almost four years ago and the launch of the first fixed transmissions in the last two years, the players have only now started implementing the middleware platforms necessary to permit interactivity, consequently bringing mobile operators into the value chain as a return channel provider. Mobile TV and Mobile Services during 2014 World Cup are likely to share the same device but stay in different ecosystems (TV and telecom).

We believe that Mobile Social Networking, not just fixed Internet access to Social Networks, will be the most important mobile data service by 2014. This is a mobile data service definition more specific to the mobile ecosystem, looking at the importance of the context on the services offered.

One reason to believe in the success of Mobile Social Networking is that, unlike the uptake of SMS, Brazilian Internet users adopted social networks to a deeper degree than many other countries. Brazilian data point to the fact that users spend far more time on social networks than any other Internet application. This behavior may have huge impact on network traffic by 2014, which will demand more frequency bandwidth, network infrastructure optimization and contingency planning to guarantee the availability and quality of service.

Last but not least, because this is a worldwide sporting event and performed in a number of cities that will receive many foreign visitors, roaming is a service that must be considered carefully.

DEMAND FORECAST AND TRAFFIC ESTIMATES

By all indications, the Brazilian cell phone system will be based on HSPA and LTE technology in 2014.

It is possible to run simulations to determine the approximate rate these technologies would deliver under real working conditions. In the case of a 3G cellular phone system operating in a 2 X 5 MHz channel in an urban area under different traffic conditions, it was found that the maximum cell throughput is approximately 9 Mbps for LTE and approximately 8 Mbps for HSPA. If it would be possible to allocate 2 X 20 MHz of bandwidth (to do this, current spectrum assignment practices would have to change), maximum cell throughput would reach 36 Mbps for LTE and 32 Mbps for HSPA.

During the 2014 World Cup, the most critical situation will very likely be covering the stadiums and surroundings, where there will be a very high concentration of subscribers, most of whom will be heavy service users. With some reasonable estimates for user density in the vicinity of the stadiums, the demand is expected to reach17 Mbps per cell area.

Even considering that changing system parameters might possibly improve network performance, it is very unlikely that HSPA or LTE cells, with a 2 X 5 MHz bandwidth, will be able to meet this demand. However, a cell with a 2 X 20 MHz bandwidth would be able to handle this amount of traffic without a problem.

An alternative way of increasing data transmission rates in areas of great user concentration, such as stadium surroundings, would be to increase the number of cells. This would, however, increase interference among the cells due to their proximity, causing system degradation and diminishing sector throughput.

Frequency Spectrum

The implementation of a cellular communications system involves a series of stages, from planning to completion. Significant time must be dedicated to the planning stage. All definitions that are necessary for implementation, such as the available frequency spectrum, must be made well in advance.

Today, the total spectrum utilized by PMS (Personal Mobile Services)[1] in Brazil is approximately 300 MHz. A study carried out by ITU (International Telecommunication Union)[2] estimates that in 2015, mobile telecommunications services will need over 1.0 GHz of spectrum to meet market demands. The frequency bands for mobile communications in Brazil are distributed in the following manner: 850 MHz; 900 MHz; 1700 MHz and 1800 MHz; and 1900 MHz and 2100 MHz (reserved primarily for 3G).

To be able to offer higher traffic rates, larger spectrum bands would have to be allocated. Following an ITU recommendation, in 2009 Anatel launched a public consulting project in order to assign 140 MHz in additional spectrum to PMS in the 2.5 GHz band (2500 MHz - 2690 MHz). Dedicated to mobile data, this additional bandwidth will be crucial for mobile data transmission at both the 2014 World Cup and the 2016 Olympic Games.

It’s important for Brazil to follow continue analyzing the situation in order to define the proper spectrum utilization to meet the increased demand for mobile communications traffic during the 2014 World Cup. Service providers and other entities that represent mobile technology suppliers can help Anatel evaluate the most viable options to comply with the mobile broadband frequency needs.

Risk Management, Critical Infrastructure Protection and Information Security

Large sporting events like the 2014 World Cup demand painstaking procedures, involving government, private initiative, and members of society in general, since they are the main stakeholders. It is not sufficient to simply estimate the volume of traffic and demand; instead, networks must be carefully planned out, taking into consideration all the risks involved, especially those posed by new emerging threats that might affect the quality and availability of existing mobile services.

The 2014 World Cup will take place in a convergent world with total mobility, and Brazil must be prepared to face a whole new set of threats. Events of great magnitude are always opportunities for new services, but also for new scams. The problem of cell phone cloning has been resolved; however, now hackers are using cell phones to steal identities, and this is becoming an increasingly critical problem.

The increased importance of information risk management is clear all along the entire telecommunications value chain. Not only must the reliability and integrity of communications be preserved, but service availability as well. In times of new emerging threats, high-quality telecommunications services are not just a question of properly working equipment or operational efficiency. To achieve this, a risk management system that can identify, assess and deal with existing risks is one of the most vital factors.

A proper risk management system cannot be limited to accidents or natural disasters, since these are already efficiently handled by the operators. It must also include intentional threats, which are proliferating rapidly thanks to the new possibilities and opportunities (both legal and illegal) made possible by new technology and services. Opportunities must also be delineated according to this risk assessment. A major sporting event like the 2014 World Cup opens up a host of new threats to be identified and analyzed, so operators can provide spectators, tourists, athletes, committees, journalists and the Brazilian population as a whole with hig-quality and uninterrupted telecommunications services.

Critical Infrastructure Protection is a concept that relates to the preparedness and response to serious incidents that involve the critical infrastructure of a nation or region. It consists of a security strategy to prevent basic services such as energy, transportation, water, health care and even mobile telecommunications from being disrupted. Critical infrastructure systems can be damaged, destroyed or disrupted by deliberate acts of terrorism, natural catastrophes, negligence, accidents, acts of piracy, among other threats.

One of the most important things needed to organize a major sporting event, or for the development of the country in general, is to have a solid knowledge of the priorities of essential services such as telecommunications, founded on the social and economic needs of all the stakeholders. This knowledge is fundamental for developing effective Critical Infrastructure Protection. With a proper view of risks and opportunities, investments can be prioritized and the right strategy implemented to guarantee the continuity of vital services.

This concept is not only critical not only for a nation's development, but also for major sporting events like the 2014 Brazil World Cup and the 2016 Olympics in Rio de Janeiro. The first major experience with Critical Infrastructure Protection in Brazil was during the Pan- and Parapan-American Games in 2007, hosted by the city of Rio de Janeiro[3]. MI²C, provided by the PICT (Telecommunication Infrastructure Protection) Project, was used to assess the critical telecommunication infrastructure.

In preparation for the Olympic Games and Para-Pan American Games, the International Olympic Committee (IOC) provided a "book of practices" for information security. Similarly, for the 2014 World Cup and for the 2016 Olympic Games, as disclosed in the application file, Brazil should implement a CTIP project (Critical Telecommunications Infrastructure Protection Project). In addition, FIFA should also provide a "book of best practices" for the event.

Recommendations

Major sporting events, such as the World Cup and the Olympics, are tremendous opportunities to spark economic growth, since both the government and the private sector invest heavily in preparation for them, leaving a legacy of development for the host country.

When it comes to telecommunications, we see a great opportunity to increase both capacity and data speeds in Brazil's mobile networks. Guaranteeing the security and reliability of mobile networks for these large events is also crucial. The following recommendations are designed to benefit the entire mobile services value chain:

- **Planning jointly between the government and the private sector:** To ensure the security and reliability of mobile networks in particular and telecommunications networks more broadly, mobile operators, together with the association of cities representing the 12 host cities and the major event sponsors, must agree on the possible locations for the eventual Fan Fests. Planning for the traffic and capacity of the networks must be aligned with the expectations of security and transportation agents.
- **Structuring partnerships with organizers of similar events:** The experience from other major sporting events is essential for the Brazilian players to acquire the needed expertise to plan and execute these events to ensure their complete success. It is vital to seek partnerships with bodies such as the organizing committees of similar upcoming events, such as the South Africa 2010 World Cup and the London 2012 Olympic Games, or of previous events such as the German 2006 World Cup, the China 2008 Olympics and the Canadian 2010 Winter Games. Telecommunications service providers that covered these events or are planning future ones can provide valuable contributions to the 2014 World Cup in Brazil as well as the 2016 Rio de Janeiro Olympics. These partnerships can provide benchmarks and other parameters such as case studies and forecasts for planning and execution purposes.
- **Acquiring hands-on experience from similar upcoming events in Brazil:** The Military World Games 2011 and FIFA Confederations Cup 2013, both large sporting events in Brazil, represent challenges to the telecommunications players. Gaining from this hands-on experience can contribute significantly to the planning and execution of the 2014 World Cup and the 2016 Olympic Games.
- **Planning for innovative new services:** Mobile carriers, broadcasters and soccer team associations can use the next state and national championships – between 2011 and 2013 – to try out new services and applications based on broadband access and mobile TV. Real network traffic requirements can thus be forecasted and important aspects regarding usability, appeal, security and end-user quality of experience can be defined.
- **Planning capacity and traffic demand:** Detailed planning must be carried out beforehand regarding what services will be offered during the World Cup and their respective impact on traffic demand and processing capacity, considering the user profile, the estimated demand for roaming, and concentrated areas of high usage such as the stadium surroundings and Fan Fests. The Fan Fests that will take place during the 2010 World Cup (South Africa) will be an excellent opportunity for Brazil to evaluate the infrastructure needed to provide users with the best possible service. Event planning must also include suppliers' delivery and execution capacity. Another critical area will be media centers at the stadiums and cities, where traffic demand from Brazilian and foreign media professionals will be huge.
- **Allocating the frequency spectrum:** There is strong evidence that the frequency spectrum currently allocated in Brazil for mobile services will not be able to adequately cover the areas of great user concentration in the next few years. Anatel is taking actions in compliance with ITU recommendations to align Brazil's mobile service frequency spectrum with that of other countries around the world. An example is the 2.5 GHz band. For the 2014 World Cup and the 2016

Olympics, the importance of an adequate new band for mobile communications is underscored by the great concentrations of users with a high demand for mobile services. It is therefore highly recommended to continue seeking and evaluating different alternatives to increase the frequency spectrum for mobile services, such as the allocation of 140 MHz spectrum band for FDD in the 2.5 GHz in a timely fashion.

- **Adopting a model of critical infrastructure protection:** Using a critical infrastructure protection model will allow joint planning between the government, telecommunications service providers and the 2014 World Cup organizing committee to ensure that mobile services will work flawlessly during the event. This model must encompass at the very least the following activities: identification and analysis of the main assets; identification and analysis of the main threats and vulnerabilities of the environment, in the context of the 2014 World Cup and the 2016 Olympics; analysis of the interdependency of the different sectors; risk analysis; and finally, the creation of an ideal scenario for critical infrastructure protection.
- **Defining contingency and business continuity strategies, based on delineated threats:** Once the critical infrastructure model has been defined, it is highly advisable to delineate contingency and business continuity strategies to improve the ability to react quickly and resolve problems. It is therefore crucial that, before risks are analyzed, this plan be defined, implemented and, most important of all, tested. Furthermore, all input from the organizing committee and information from FIFA itself, such as game databases, credentials and any other pertinent data, must be taken into consideration.
- **Conducting in-depth analysis among all market players:** Each player should be developing an in-depth analysis to define the best solution for mobile users. This analysis might reveal that more frequency bands will be needed if the other factors involved (e.g., data compression or transmission technology) do not evolve sufficiently to meet increased traffic demand. A common strategy among all players, however, is essential to secure the necessary measures from federal, state and local governments.

1 INTRODUCTION

Hosting the 2014 World Cup represents a historical point for Brazil, opening up a wide range of challenges and opportunities. Large sporting events such as the World Cup and the Olympic Games are a major undertaking, demanding initiative, investment and oversight from the government, the various segments of the economy and from the society itself.

Hefty investments in infrastructure will be needed and companies will face a unique opportunity, not only because of the millions of people from all over the world who will flock to Brazil, but because of the high level of exposure the country will receive. In the telecommunications sector, convergence and mobility are changing the way people access information. In this scenario, new services will demand new technology and innovative business models. The 1998 World Cup in France was marked by wide-scale digital transmission, while the 2006 World Cup in Germany was characterized by TV and cell phone convergence. For the 2014 World Cup, with the trend for mobile devices such as smartphones to be the most widely used means of communication, telephone companies should be ready to offer new services and to generate and transmit full HD and 3D multimedia packets in real time.

The success of telecommunications companies in the 2014 World Cup also hinges on the quality and availability of the services offered to ticket holders, media personnel, organizing committee staff and the population in general. To ensure quality and availability, planning must include not only traffic demand, bandwidth and user profiles, but also security aspects arising from new emerging threats that come with technological evolution.

The scale and scope of the infrastructure demanded by FIFA to host the 2014 World Cup games is a real challenge. The enormous influx of people into the host cities increases the need for various basic services such as transportation, telecommunications, water distribution, sanitation, electric power distribution, financial services and health care. These systems are interdependent, and an incident in one area can have critical consequences on the others. For instance, power failures can lead to the forced shutdown of telecommunications networks.

The concept of critical infrastructure protection, used to identify the critical telecommunication services during the 2007 Pan-American Games in Rio de Janeiro, will be vital for the 2014 World Cup.

2 CONTEXT

2.1 BRAZIL

The country of the moment is Brazil. A series of events has demonstrated the country's capacity to progress and attract the attention of the whole world. The record highs of the Brazilian Real (R$) and stock market in 2009, the pre-salt oil layer discoveries that put Brazil among the largest reservoirs of petroleum in the world, the World Cup of 2014, and the 2016 Olympics in Rio de Janeiro all demonstrate the country's enormous potential.

A country of continental dimensions (a little over 8.5 million km^2), Brazil today is the eighth-largest economy in the world. Its current gross domestic product (GDP) of 3 trillion reals[4] (the Brazilian local currency) is expected to grow to 4.7 trillion by 2014, the year of the World Cup. The Brazilian population will grow from the current 194 million to 206 million in 2014, with life expectancy increasing from 72.8 to 74.5 years. Per capita income is expected to reach 22,000 reals in 2014, compared to 15,500 in 2009. In the telecommunications sector, there were 190 million fixed and mobile lines in the country in 2008, and this number is forecast to hit the 300 million mark in 2013[5].

The legacy of a World Cup for Brazil will go far beyond social, economic and political gains. Certainly, the country expects to benefit from a better distribution of income, more housing, higher-qualified human resources in the hotel, tourism and restaurant sectors, new job openings in several areas of the economy, new international opportunities for the country's businesses, and improved highways, railways and subways. In addition, with real-time transmission of the games to billions of TV viewers, and tens of thousands of tourists and journalists coming to watch the games live in the 12 host cities, the country will become the center of the world's attention. Permanent benefits include significant progress in the telecommunications sector. The mobile phone sector in particular must be prepared to meet the increase in demand from the caused by the millions of people that will descend upon the country for the 30 days of the 2014 World Cup.

2.2 THE 2014 WORLD CUP

The World Cup is one of the greatest sporting events in the world. With 208 members, FIFA has more member countries than the United Nations, which has 192 members. Together with the Olympic Games, it is the most-watched event in the world, generating the greatest revenues. Considering direct revenue (such as transmission rights and sponsorships) and indirect revenue (such as tourism and building projects), the Olympics generate revenue of $13 billion, compared to $10.5 billion generated by a typical World Cup and $3.5 billion by a complete Formula 1 Season. During the 2006 World Cup in Germany, FIFA pulled in $2.9 billion through TV rights, publicity, tickets and licensed products alone[1].

The 12 host cities for the 2014 World Cup in Brazil are: Belo Horizonte, Brasília, Cuiabá, Curitiba, Fortaleza, Manaus, Natal, Porto Alegre, Recife, Rio de Janeiro, Salvador and São Paulo.

Germany also had 12 host cities. Moving around from city to city was easier thanks to Germany's excellent transportation infrastructure of highways and trains. Furthermore, the German territory (357,000 km^2) is only slightly larger than the state of Goiás, a Center-West Brazilian state, giving one an idea of the contrast presented by the continental dimensions of Brazil. By comparison, Brazil has 27 states and a territorial extension almost 24 times larger than Germany.

Therefore, hosting the World Cup in Brazil will require considerable investments in infrastructure. The government is currently planning investments in the order of 25 billion reals in key sectors, but this number could easily reach 100 billion reals. Germany invested the equivalent of approximately 60 billion reals to prepare for the 2006 World Cup[6].

Thirty-two national soccer teams will compete in Brazil in 2014. They will be chosen in qualifying matches that begin years before the great event. Matches are viewed around the globe; the World Cup in Germany was transmitted to 214 countries. An estimated 26 billion viewers[7] around the world watched the 64 games of the 2006 World Cup on television. The final tally amounted to 71,000 hours of broadcasting, with 18,850 newspaper, radio and TV professionals covering the event[3].

To comply with FIFA's technology requirements for stadiums and their surroundings, telecommunication companies are expected to invest close to 3 billion reals[3]. With the advent of new services and the expected increase in users, mobile telephone companies are faced with a great opportunity that justifies the expansion of infrastructure. This takes on even more importance when we take into consideration the momentum that the World Cup will bring to the Brazilian economy.

During the 1950 World Cup, also hosted by Brazil, the final match between Brazil and Uruguay gathered almost 200 million spectators in the Maracanã Stadium in Rio de Janeiro. The stadium will be renovated for the 2014 World Cup. The stadium capacity will be decreased from 87,000 seats to a little over 82,000 seats, all numbered. In a scenario of great mobility, in which direct access to a wide range of services will play an intrinsic part of people's day-to-day activities, this is the estimated potential number of cell phone users in the stadiums.

Besides the stadiums and their surroundings, with their great crowds of people during the games, other World Cup-related festivities and tourist attractions will present mobile phone operators with both opportunities and challenges. Among the most popular of these are the Fan Fests.

Fan Fests were created by FIFA during the 2006 World Cup in Germany, and were inspired by the crowds of people who gathered to watch games in public places during the 2002 World Cup games in Japan and South Korea. In the 2010 World Cup in South Africa, an estimated 400,000 people will watch the first match on the streets of 16 cities in different parts of the world. The forecast is that over 25 million people will have watched the games in these Fan Fests, which are open-air stadium extensions that FIFA organizes to broaden access to the games and attract young people who are unable to go to the stadiums[3].

It is estimated that in 2010 the number of Fan Fest spectators will be six times greater than that of those in the stadiums. In 2006, Fan Fests were set up in 12 different places in Germany, with a total of 18 million people watching the game on giant screens. In 2010, there will be Fan Fests staged outside the host country in London, Paris, Sydney, México City, Berlin, Rome and Rio de Janeiro. In Rio de Janeiro, it will cost 25 million reals for the organizers to gather 20,000 spectators per game on Copacabana beach[3].

In Brazil, popular festivals such as the Alzirão, in the Tijuca neighborhood in Rio de Janeiro, have existed since the 1970s. Approximately 20,000 people gathered to watch the Brazilian national team on a big screen during the 2006 World Cup in Germany. Another festival is the "Festão da Copa" (Big World Cup Festival), which is scheduled to be held at the Ibirapuera Gymnasium in São Paulo during the 2010 South Africa World Cup[8].

2.3 TELECOMMUNICATION NETWORKS IN BRAZIL

In Brazil and in the rest of the world as well, fixed telephony access is on the decline. Mobile networks, on the other hand, will tend to expand as mobile telephony access increases. Although this growth is beginning to show signs of saturation in developed countries, there is still a lot of potential in emerging countries. As an alternative to their declining market, fixed telephony providers are investing in broadband Internet access, but are facing competition from subscription cable TV operators. Simultaneously, mobile providers are also investing in infrastructure and technology to enter the broadband access market, in line with the trend toward convergence.

Telecommunications network access will increase in the coming years[9]. The main product of telecommunications companies, responsible for generating the greatest revenues, used to be fixed telephony services. In 1995, developed countries already boasted high rates of fixed phones per person, as can be seen in Figure 1, while in developing countries like Brazil, this rate was under one phone line for every ten people. Between 1995 and 2005, there was a marked increase in the number of fixed telephone lines in developing countries. The higher growth rate in developing countries is explained by the low penetration, meaning there was still a lot more room for growth. In 2000, practically all developed countries began experiencing a decrease in fixed-line telephones, and developing countries also are starting to show signs of saturation. In Japan, the number of fixed telephone lines actually decreased between 1995 and 2005.

The decreasing number of fixed telephone lines is directly related to the rapid increase of mobile telephone users. At first, these two services did not compete for the same market. An examination of network traffic statistics reveals that the growth of mobile network traffic is much greater than the decline of fixed network traffic[10]. However, as the high mobile service rates began to fall – thanks to economies of scale and competition – many users began to replace their fixed phones with mobile services.

Figure 2 shows the evolution of mobile phone access for the same set of countries a Figure 1, including Brazil. Due to the fact that mobile telephony was launched much later than fixed telephony, the average annual growth rate is still very high in most countries. As in the case of fixed lines, mobile teledensity was significantly lower in underdeveloped countries before 2000, compared to first-world countries. Therefore, in countries like Brazil, the average annual growth rate of the mobile phone market is up to four times higher than that of developed countries.

In spite of very high growth rates, Brazil's rate of cell phones per 100 people in 2008 was still lower than that of European countries; though closer to that of Japan and the United States, where the penetration of mobile services has systematically been lower than in Europe.

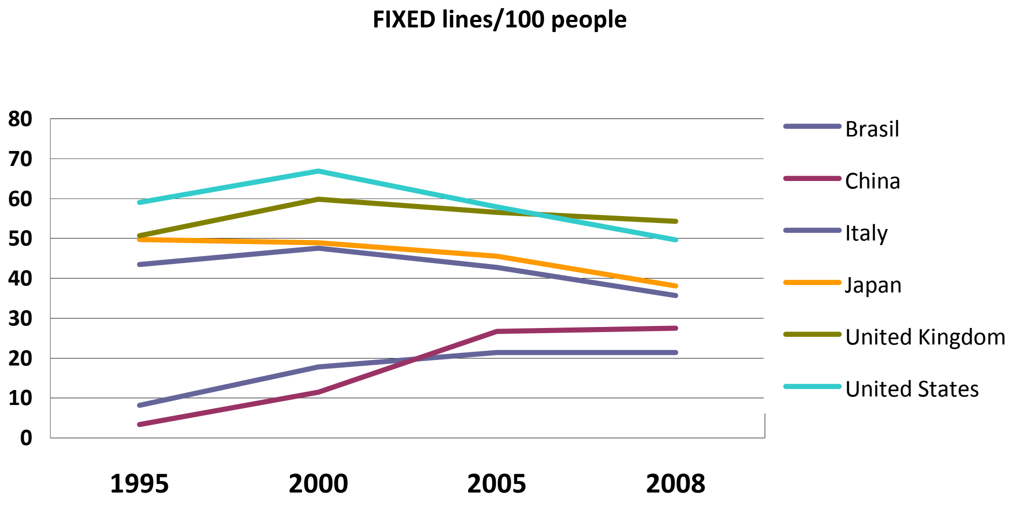


Figure 1 Fixed-line teledensity in selected countries

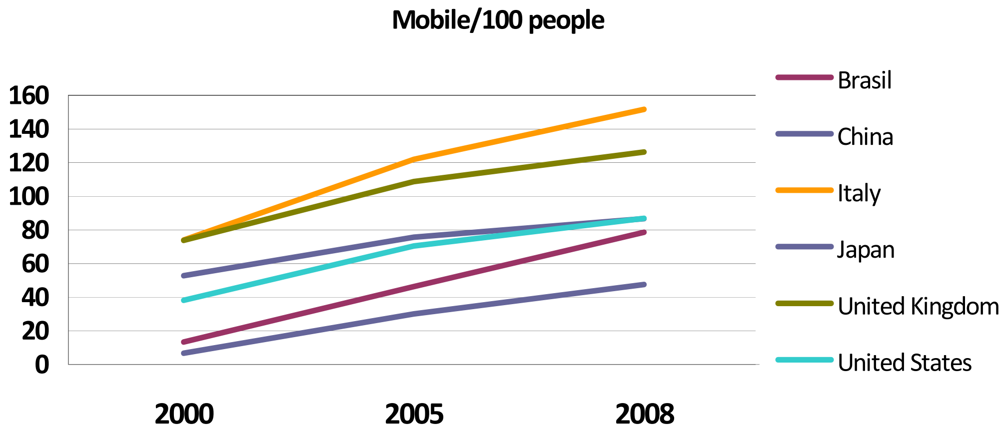


Figure 2 Mobile teledensity in selected countries[11]

This shift in telephone access, with the saturation and eventual decline of the fixed telephone segment, caused fixed-line companies to lose revenue to new entrants in the mobile market. As a defensive strategy, they began to see the emergent broadband Internet access market as an opportunity to get a bigger piece of the pie in telecommunications services.

Mobile telephone carriers reacted to the near-saturation of their market by setting their sights on the same broadband Internet segment. They began to enhance their networks in order to offer 3G services, providing fast Internet access over mobile networks.

Convergence has brought a whirlwind of transformations to the telecommunications sector. Despite its widespread use, there is not yet a universal definition for the term. This is due to the fact that it is a multidimensional process, of which the most important aspects are the technological, marketing, and regulatory facets[12]. Convergence can intensify competition and help reduce access bottlenecks, by allowing telecommunications services to be delivered by an ever-increasing number of different platforms. It can also generate new services and stimulate innovation as new players appear on the scene. Convergence is also associated with the vertical integration of global companies; if these companies control the gateways, it will be hard for newcomers to get in.

Figure 3 show the evolution of broadband Internet subscribers and teledensity in selected countries from 2000 to 2008. The growth rates are expressive and higher than those of mobile telephone services.

The number of connections is the sum of all the different access technologies, such as Asymmetric Digital Subscriber Lines (ADSL), Cable modems, wireless and fiber optic cable. Fixed telephony companies use DSL technology, while cable modems are the option offered by subscription TV operators. The other technologies are used by these same players or by alternative operators.

As fixed telephone companies worked to offer broadband Internet access to mitigate their losses from the substitution of fixed telephony for mobile or VoIP services, they ran into unexpected competition from cable TV operators. In some countries like the United States, the market share of cable modem access technology is quite significant.

It is also important to remember that in developing countries such as Brazil, the number of Internet subscribers is limited by the number of homes with computers, a relatively expensive terminal for the average family's standard of living. At this moment, mobile broadband services yet target a different subscriber segment in these countries than the huge market of pre-paid services running over plain vanilla devices, focusing on more sophisticated terminals and more expensive post-paid plans.

2.4 Mobile networks in Brazil

The privatization of telecommunications in Brazil took place on July 29, 1998 in an auction at the Rio de Janeiro Stock Exchange. The Telebrás System, assessed at R$ 13.47 billion, was sold for R$ 22 billion and split up into 12 companies, including three local fixed telephony operations, one long-distance carrier and eight regional mobile telephony operators[13].

Following the privatization, new companies were granted permission to compete with fixed and mobile telephony license holders, more than doubling the number of players at that time. New mobile telephony concessions were more successful than the fixed ones, but the segment has gone through a phase of consolidation, marked by mergers and acquisitions similar to what is taking place internationally. Furthermore, several companies in the segment are vertically integrating themselves in the value chain, offering value-added service bundles such as Internet access and subscription TV, for instance.

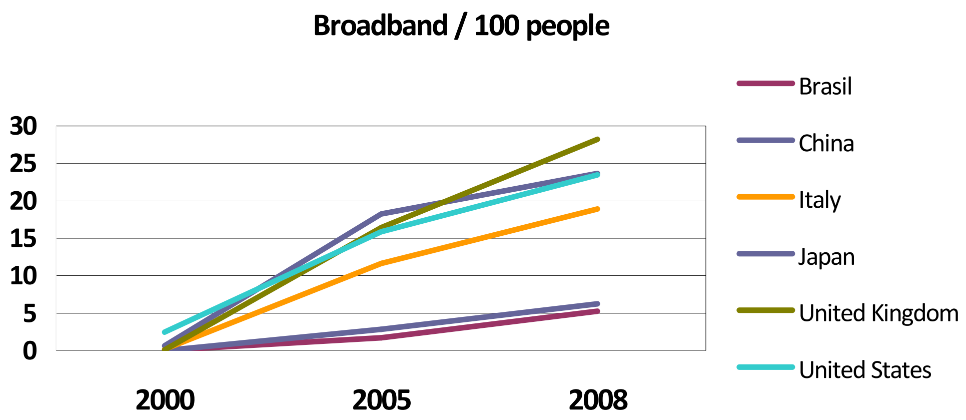


Figure 3 Broadband in selected countries[14]

In spite of being a dynamic area, the main segments of Brazil's telecommunications sector today are concentrated in the hands of a few players. Four companies control the mobile sector: Vivo, an association of Telefonica and Portugal Telecom; Claro, controlled by América Móvil; TIM, a subsidiary of Telecom Italia; and Oi, a Brazilian-owned telco.

Vivo still has the largest market share, although its share has declined in recent years. Figure 4 shows the market shares of the four main mobile providers in February 2010, when the country reached a total of 176,771,038 accesses lines, according to Anatel.

In terms of geographical coverage, 5,094 of the country's 5,564 municipalities are serviced by mobile telephony (at least on their urban area). Since the population is concentrated in the large urban centers (Brazil is 80% urban), only two states in Brazil (in the Amazon forest region) have coverage rates of less than 90% of the population. Approximately 96.6% of the population is serviced by at least one operator, while 64.7% can choose between at least four alternatives[15].

In the previous section we pointed out that similar to other countries, mobile networks in Brazil grew explosively from 1995 to 2005, and continued delivering high growth rates from 2005 to 2008. This is typical of developing countries, whereas developed countries are beginning to show signs of saturation in the mobile telephony markets. Developing countries are able to reach high levels of teledensity thanks to innovative business models such as pre-paid services that help overcome barriers like modest purchasing power among people with lower income.

In the case of Brazil, as it can be seen in Figure 5, the growth of wireless penetration has largely been driven by the implementation of pre-paid services, providing the less affluent with access to telecommunications services. Mobile telephony reached 176.8 million subscribers in February 2010, of which 82.5% are pre-paid and 17.5% post-paid[16]. Figure 5 shows the growth of mobile accesses lines in the country during the period from 2002 to 2009. Today the number of mobile service subscribers outnumbers the number of fixed phone subscribers. It's important to note that in developing countries, with lower penetration rates of fixed telephone networks, mobile telephones are a replacement for fixed telephones, rather than just a complement.

Pre-paid mobile services help provide universal individual access to telecommunications services and show the importance of a pricing mechanism for a product to evolve.

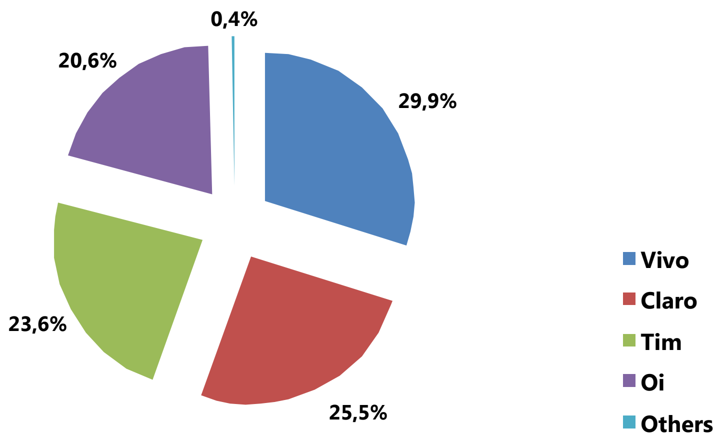


Figure 4 Brazilian mobile providers market shares[17]

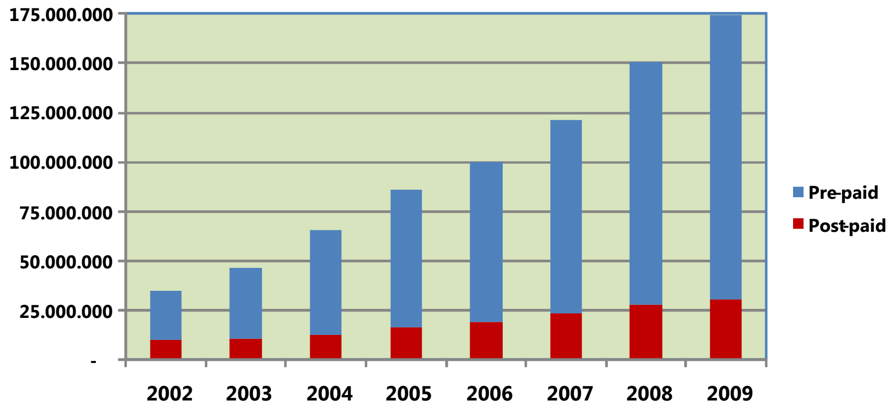


Figure 5 Evolution in the number of mobile cell terminals[18]

3G mobile services were launched in Brazil in late 2007. Licenses for this new technology were auctioned in December 2007, and as was expected, the winning bids came from current mobile telephony licensees.

The auction notice created mechanisms making it possible to service the entire Brazilian territory. Anatel established deadlines for 3G coverage, while linking these to goals for making 2G the universal standard, with more than 90% of subscribers using the GSM standard. Table 1 below shows the 3G coverage deadlines to which the bid winners committed.

Besides fulfilling these deadlines, the winning bidders were bound to service 25% of the cities with no mobile coverage within two years. However, they could use 2G technology to achieve this.

Table 2 illustrates the current penetration of mobile technologies in operation in Brazil. These statistics reveal that a little over a year and a half after the first 3G commercial operations were launched, there were 8.1 million WCDMA terminals in use, or 4.6% of the market – not including data terminals for portable computers with transmission rates higher than 256 Kbps. According to mobile network operators, 739 cities had 3G coverage by October 2009[19], and the deadline of five years for cities with a population of over 100,000 was already anticipated in three years.

Deadline	Binding commitment
2 years	All capitals and cities with population of over 500,000.
4 years	All cities with population of over 200,000.
5 years	50% of the towns with population of between 30,000 and 100,000 and 100% of those above this range.
8 years	60% of the cities with population of less than 30,000.

Table 1 Commitment for implementing 3G at 1.9/2.1 GHz

In compliance with their 3G commitments, 12% of the towns would be covered by December 31, 2012, representing approximately 85% of the population. In Brazil, only 266 of its 5,564 towns (or less than 5%) have more than 100,000 inhabitants, but these cities make up 63% of the population (around 122 million inhabitants).

Technology	Subscribers	Share (%)
AMPS	3.059	0
CDMA	7.163.683	4,05
TDMA	268.527	0,15
GSM	156.368.294	88,46
WCDMA	8.100.193	4,58
Data terminals	4.867.282	2,75
Total	176.771.038	100

Table 2 Current mobile network technology penetration in Brazil[20]

3G mobile telephony, with high speed internet connectivity, opens new market opportunities for service providers. 3G is the main reason Oi is entering the São Paulo market, in addition to covering the entire country's territory.

Furthermore, Anatel believes that in 2014 the number of mobile accesses lines in Brazil will be over 210 million, representing a mobile teledensity of over 100%, with more than 55 million being mobile broadband subscribers. The regulator's projections, based on historical data, point to an increase in the net operating revenues of the mobile sector to around R$ 100 billion in 2014, up from an estimated R$ 40 billion in 2007. To achieve these numbers, Anatel expects annual investments of R$ 10 billion from 2008 through 2014.[21]

As we can see in Table 2 , these projections for 2014 suggest a steep growth from February 2010, when there were only 11.3 million 3G terminals in use[22]. This suggests growth not only in the number of subscribers but also in the resulting spectrum needs and infrastructure investment requirements.

2.5 Mobile services in Brazil and the world

Changes and trends that have affected the recent evolution of the telecommunications sector worldwide, such as globalization, convergence, the decline of fixed telephony and the growth of mobile networks, can also be seen in Brazil. Three out of the four mobile service providers with the largest market shares in Brazil are controlled by international business conglomerates. Only the fourth-ranked company, Oi, with 21% of the market, is controlled by a national business group.

The expansion of mobile network coverage, its increasing penetration in the country, and the evolution brought about by 3G technology are all factors that tend to intensify convergence. When considering the services and applications that 3G networks propose to offer, or that have already become a reality in developed countries, three aspects of convergence described previously can be clearly seen: the convergence of service providers; the convergence of terminal equipment; and the convergence of delivery modes.

With 3G technology, mobile devices now allow users to access several kinds of services that formerly would have required different terminals. Today, mobile service providers can offer services that previously only fixed network providers could offer. With the 3G platform, different technologies (such as DSL, Hybrid Fiber Coax, wireless) can be used for the same service.

It is possible to classify the mobile services in just a few broad categories based on the bandwidth required. The three main categories are:

- Voice Services
- SMS Services
- Data Services

This classification points to two ecosystems in the process of convergence: mobile telephony and information technology (data and Internet). Voice and SMS services are typical of mobile environments, while data services generally are more related to the world of the Internet. Today, data services can be grouped into the following subcategories:

- Music and games
- Messages (e-mails, instant messaging, MMS, etc)
- Browsing (Web pages, news, etc)
- Video services (downloads, streaming and broadcast)
- Corporate services and others

3G technology, and its evolution, is essential for the development of data services in a mobile environment, since it offers high-speed Internet access.

The proliferation of new applications and the trend toward changing user profiles are still in the very early stages, if you consider the revenue of the sector as a whole. The impact of the evolution of telecommunications service access on the sector's revenue can be observed in Figure 6. This figure shows the worldwide revenue evolution of fixed and mobile telephony, Internet access and data services (for fixed networks) between 2005 and 2009 (forecast).

The growth of the data and Internet markets (for fixed networks) has barely compensated for the decline in fixed telephony, while the growth of the sector as a whole has been sustained by the mobile segment. The growth of mobile services is sustained by the expansion of the subscriber base, while average revenue per user has decreased. However, this growth is beginning to show signs of saturation in developed countries, leading mobile providers to begin exploring the data and Internet access markets.

From the point of view of user acceptance, and consequently, generated revenue, one can say that the services were listed in decreasing order. The vast majority of users in the world, and in Brazil too, use their mobile phones mainly for voice communications. Next come SMS messages, and finally data services. The first applications offered by data services were music and game downloads, followed by MMS and, with the advent of 3G, Internet browsing. Corporate services are niche applications, and video services are not only just beginning to take hold, but face regulatory issues in Brazil as well.

Nielsen Mobile Insights conducted a survey of Brazilian mobile service users, which revealed that 16% use their cell phones strictly for voice calls; 37% for voice calls and built-in applications that don't need Internet connectivity (such as calendars); 26% for voice calls and SMS; and, finally, only 19% use them for the so-called value-added services (VAS).[23]

Among VAS users, 94% of all mobile Internet access is strictly for multimedia downloads, 13% is for Web browsing and 11% is for game downloads. Surveyed users were allowed to select more than one alternative. Of those who access multimedia, 36% download ringtones, 29% complete songs, 28% wallpapers and 19% images and photos.

For 3G subscribers in Brazil, USB data modems provide access to the Internet. Some subscribers choose mobile broadband service to fit their lifestyle, while others use it to compensate for poor coverage of fixed networks. Adoption rates of USB data modems can be seen in Table 2. As pointed out in footnote 16, it is reasonable to assume that at least two-thirds of these data terminals use 3G technology, which could represent more than 40% of the WCDMA/HSPA subscriber base.

With convergence, the sector's value chain becomes even more complex, creating the need for new functionality associated with producing and programming digital content. It is not yet quite clear who will execute these functions, or what strategies the current players in the broadcasting and telecommunications sectors will implement.

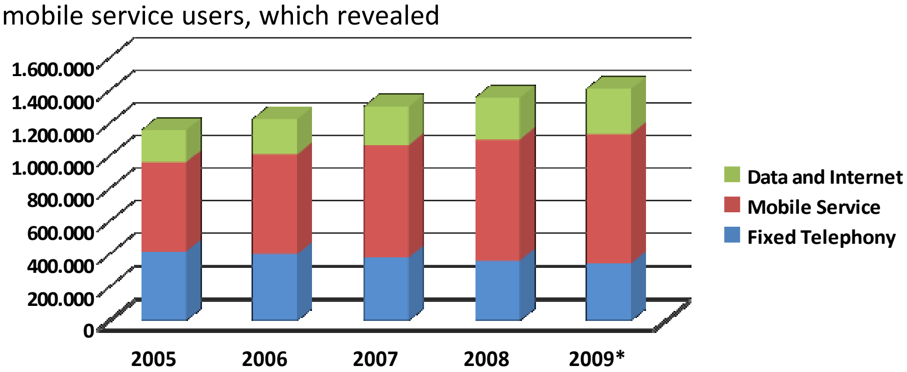


Figure 6 Evolution of telecommunications services revenue[24]

2.6 SECURITY

The advent of new technologies opens up great opportunities for telecommunications companies, but at the same time it presents new threats. Users always try to get the most out of their services, both in terms of technology as well as serviceability. From this viewpoint, availability is also a security issue, along with data confidentiality and integrity.

The most important way to guarantee security is to implement a set of controls effectively based on the main existing risks. This means that the risks must be identified. They also change according to the operator's specific technologies, services and contexts. Service disruption used to be caused by equipment failure, natural phenomena or human error. Today, new threats are increasing more and more, thanks to the opportunities for illicit profits that new technologies offer. There were recent cases of this in Brazil when Speedy[25] and Oi[26] services were disrupted.

The 2014 World Cup will take place in a convergent world with total mobility, and Brazil must be prepared to face a whole new set of threats. Events of great magnitude are always opportunities for new services, but also for new scams. The problem of cell phone cloning has been resolved; however, now hackers are using cell phones to steal identities, and this is becoming an increasingly critical problem.

3 CRITICAL INFRASTRUCTURE PROTECTION

3.1 SOCIAL AND ECONOMIC ASPECTS

Critical Infrastructure Protection is a concept that relates to the preparedness and response to serious incidents that involve the critical infrastructure of a nation or region. It consists of a security strategy to prevent basic services, such as energy, transportation, water, health care and even mobile telecommunications from being disrupted.

The telecommunications sector as a whole is one of Brazil's most important infrastructures. It consists of several different services, such as fixed telephony - STFC[27], mobile telephony – SMP[28] and data services – SCM[29], among others.

This concept is not only critical for a nation's development, but also for major sporting events like the 2014 Brazil World Cup and the 2016 Olympics in Rio de Janeiro. It was already used during the 2007 Pan-American Games, in Rio, which gives Brazil experience to build upon.

The social aspects have to do with the use of telecommunications services by society in general (personal, commerce, services and industry) and, in the context of the 2014 World Cup, by all the spectators as well, both Brazilian nationals and foreigners. It is important to remember that besides the spectators coming from all parts of the world, the inhabitants of the host cities themselves must also be taken into account.

The systems and networks that make up the infrastructure of society are often taken for granted, yet because of their interdependency, a disruption in just one of those systems can have dire consequences across other sectors. This means that damage caused by the vulnerability of a particular service, such as a hydroelectric plant shutdown, will affect other elements of the infrastructure, since the interdependency among services increases the complexity of the system. An entire region can become debilitated because some critical elements in the infrastructure were disabled by a natural disaster. The interconnectivity within a complex infrastructure like telecommunications can cause an incident affecting one service to impact other services and even other service providers.

An example of this in Brazil was when the electric power distribution in Florianópolis, a southern city, was disrupted. As a result, fixed and mobile telephone services became unreliable and the whole transportation system of the city was on the brink of chaos. More recently, in November 2009, a failure in the national power transmission system, caused by meteorological phenomena, illustrated the consequences of a chain reaction: the transportation infrastructure (subways and electric buses) ground to a halt in the largest cities of the country, stores shut their doors, hospital equipment stopped working, water distribution was disrupted in many regions, and the telecommunications system was completely overloaded. Ironically, in São Paulo, only 3G phones could provide updated news on what was happening through Internet access to news sites, as many residences and work places had no fixed access to the Internet.

Incidents involving critical infrastructure can impact the entire nation, causing problems for citizens, government, businesses and utilities. Mobile phone services are intricately interdependent with practically all other systems and networks that make up the critical infrastructure. Thus, a failure in this system will have an even greater impact, triggering a chain reaction in other services, especially those related to citizens and the economy.

Large sporting events like the 2014 World Cup demand painstaking procedures, involving government, private initiative, and members of society in general, since they are the main stakeholders. It is not sufficient to simply estimate the volume of traffic and demand; instead, they must be carefully planned out, taking into consideration all the risks involved, especially those posed by new emerging threats that might affect the quality and availability of existing mobile services.

3.2 DEFINING CRITICAL SERVICES AND ISSUES

Critical infrastructure was formally defined in Brazil in February 2008 as the installations, services or assets that if destroyed, disrupted or incapacitated will have a debilitating impact on security, the national economy, national public health and safety. Besides telecommunications, this includes sectors such as energy, transportation, water distribution and financial services[30].

Critical telecommunications infrastructure supports several services, principally fixed and mobile phones. The integration and interdependency of fixed and mobile phone lines, along with Internet access and data services, make the identification of critical points extremely vital.

In Brazil, telecommunications and broadcasting service concessions are granted and inspected by Anatel and the Ministry of Communications. Telecommunications services are[31]:

- Public Switched Telephone Networks (STFC)
- Mobile Personal Services (SMP)
- Specialized Mobile Services (SME)
- Specialized Mobile Radio Services (SER)
- Global Mobile Satellite System (SMGS)
- Aeronautical Mobile Services (SMA)
- Mobile Maritime System (SMM)
- Multimedia Communications System (SCM)

Broadcasting services are:

- Radio
- Open television (TV)
- Ancillary television services
- Cable TV (TVC)
- Multichannel Multipoint Distribution Service (MMDS)
- Direct to Home (DTH)
- Citizens' band radio
- Amateur Radio
- Radio Taxi Services

3.3 THREAT IDENTIFICATION

Threats to vital points of Brazil's critical telecommunication infrastructure, which consists of a broad range of services, can have a considerable impact on operators, users and government. To avoid them, it's crucial to have a proper understanding of these threats, be they intentional or not, technical or not, internal or external. Critical infrastructures can be damaged, destroyed or disrupted by deliberate acts of terrorism, natural catastrophes, negligence, accidents, and acts of piracy, among other threats.

Therefore, the security of all the parties involved in providing and using mobile services, when added to the government's definitions, represents a holistic view of critical telecommunications network protection.

Government, society and industry must work together to establish a set of methodologies by which the critical infrastructure can be identified, and retrieve the needed information to define regulations, strategies and policies to protect and guarantee the continuity of this infrastructure. Once this information has been collected, all possible threats must be assessed, an ideal scenario created, and all relevant elements analyzed, in order to provide the appropriate recommendations.

There is no universal model or standard for the protection of critical telecommunications networks. This is due to the fact that every country has its own focus, culture, and specific concerns. In Brazil, a project called Critical Telecommunication Infrastructure Protection has been under development since 2004 by Anatel (the Brazilian Telecommunications Regulatory Agency) and CPqD (Centro de Pesquisa e Desenvolvimento – Research and Development Center), with financing from Funttel (Fundo de Desenvolvimento Tecnológico das Telecomunicações – Brazilian Telecommunications Technological Development Fund).

3.4 Risk assessment

The 2000 Olympics in Sydney, Australia was the first major sporting event planned and carried out in compliance with risk management norms. The experience produced the AS/NZS 4360:2004 standard, which later became the basis for the International Organization for Standardization (ISO) 31000:2009 family of standards.

Risk Management must be based on different viewpoints, taking into account various strategic, operational, technological, marketing, economical and political aspects. The fundamental issue is that risks may be positive or negative, presenting threats or opportunities. All decisions must be made with this in mind.

A specific standard for information security risk management, ISO 27005:2008, must be used in telecommunications environments, since information security has become an increasingly important issue for the services provided by operators.

The increased importance of information risk management is evident along the entire telecommunications value chain. Not only must the reliability and integrity of communications be preserved, but service availability as well. In times of new emerging threats, high-quality telecommunications services are not just a question of properly working equipment or operational efficiency. To achieve this, a risk management system that can identify, assess and deal with existing risks is one of the most vital factors.

A proper risk management system cannot be limited to accidents or natural disasters, since these are already efficiently handled by the operators. It must also include intentional threats, which are proliferating rapidly thanks to the new possibilities and opportunities (both legal and illegal) made possible by new technology and services. Opportunities must also be delineated according to this risk assessment. A major sporting event like the 2014 World Cup opens up a host of new threats to be identified and dealt with to provide spectators, tourists, athletes, committees, journalists and the Brazilian population as a whole adequate and uninterrupted telecommunications services.

This highlights the importance of Critical Infrastructure Protection even more. Critical Infrastructure Protection is closely related to information security risk management. The purpose of critical infrastructure protection is to safeguard the country – in other words, its government, society and economy.

3.5 INTEGRATING PROVIDERS, GOVERNMENT AND SOCIETY

Critical Infrastructure Integration is based on the integration of government, society, and the private sector, according to the social/political/economic interests involved. The challenge is to find a way for everyone to gain from government measures and service provider investments.

The 2014 World Cup is a context in which the concepts of critical infrastructure protection must be applied, ensuring decision making in a way that will integrate the needs and desires of all those involved.

4 CASE STUDY – THE 2007 PAN-AMERICAN GAMES IN RIO DE JANEIRO

In 2004, Anatel and CPqD began a joint research project on Critical Infrastructure Protection, called National Telecommunication Network Safety[32].

The current CTIP (Critical Telecommunication Infrastructure Protection) project consists of five methodologies[33]: the Methodology for Critical Infrastructure Identification (MI²C), the Methodology for Identifying and Analyzing Threats (MIdA²), the Methodology for Analyzing Critical Infrastructure Interdependency (MAI²C), the Methodology for the Creation of the Ideal Scenario for Critical Infrastructure (M(CI)²C) and the Methodology for Critical Infrastructure Methodology (MeDI²C), as illustrated in Figure 7. The first major experience with Critical Infrastructure Protection was during the Pan- and Parapan-American Games in 2007, hosted by the city of Rio de Janeiro[34]. MI²C was used to assess the critical telecommunications infrastructure. The scope defined for the analysis was temporal and localized; in other words, it was limited to the critical telecommunications infrastructure in the regions where the games where being held, for the duration of the events.

After the 2007 Pan-American Games, this system is being implemented all over Brazil as an Anatel initiative involving all the service providers in the country.

4.1 METHODOLOGY FOR CRITICAL INFRASTRUCTURE IDENTIFICATION (MI²C)

One of the most important things needed to organize a major sporting event, or for the development of the country in general, is to have a solid knowledge of the priorities of essential services such as telecommunications, founded on the social and economic needs of all the stakeholders. This knowledge is fundamental for developing effective Critical Infrastructure Protection. With a proper view of risks and opportunities, investments can be prioritized and the right strategy implemented to guarantee the continuity of vital services.

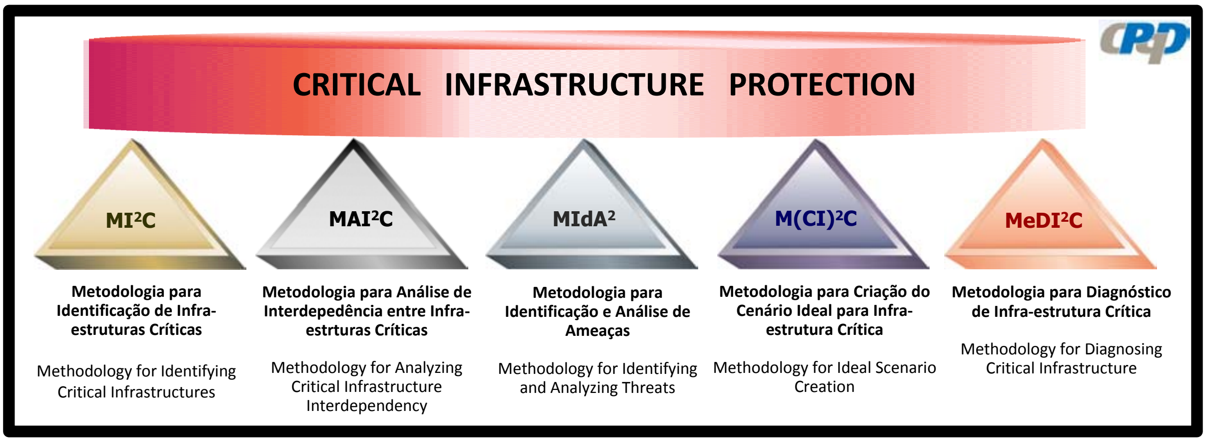


Figure 7 PICT Project Methodologies

MI²C, which was used in the 2007 Pan-American Games, identifies critical infrastructures, producing a list of elements in a telecommunications station ordered by severity level. This station is in turn defined based on an assessment of the services it provides, considering aspects related to its area of operation, social interests and the interests of the state.

Figure 8 illustrates the eight stages of MI²C: identifying and defining telecommunication services (Stage 1); defining the aspects to be assessed for each service defined in Stage 1 (Stage 2); defining severity levels (Stage 3); defining the weight of each aspect specified in Stage 2 (Stage 4); analyzing severity levels (Stage 5); mapping and prioritizing critical telecommunications services (Stage 6); identifying and defining telecommunications network infrastructures (Stage 7); and mapping and prioritizing critical telecommunications infrastructure elements (Stage 8). The first five stages define severity levels for telecommunications services. Stage 6 maps the critical services, based on the list generated by the previous stages. Stages 7 and 8 consolidate the final results, with a list of the most critical telecommunications infrastructure.

4.2 Identifying services

In this stage, all the telecommunication and broadcasting service concessions, granted and inspected by Anatel, are identified.

4.3 Defining aspects

During this stage, the aspects to be used to assess each telecommunications service defined in Stage 1 are specified. These aspects indicate user, society and state interests in the services provided.

In the case of the 2007 Pan-American Games, Table 3 shows the eight aspects that were used, sorted in three groups: two had to do with the service itself (scope and population serviced), two were associated with social interests (exposure, and social and cultural impact) and the remaining four indicated aspects of government interest (public health and emergencies, security, civil defense and economy).

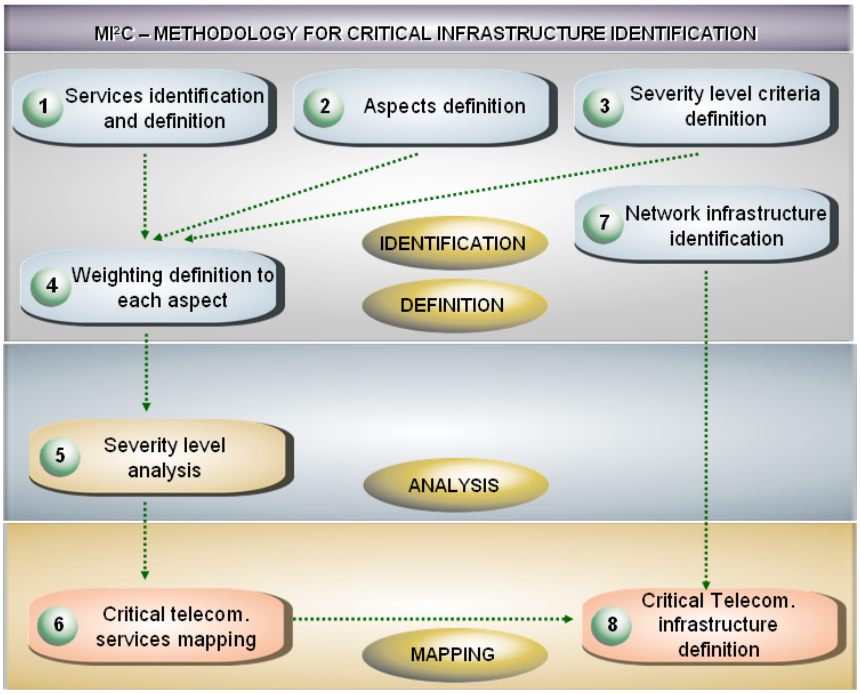


Figure 8 MI²C stages

Aspect	Type	Definition
Scope	Quantitative	Percentage of geographical coverage area.
Population Serviced	Quantitative	Percentage of total population (local plus visitors) serviced.
Publicity	Qualitative	Amount of service used to generate and transmit information about the 2007 Pan-American Games.
Social and cultural Impact	Qualitative	Amount of service used to increase cultural awareness.
Health and Emergency	Qualitative	Amount of service used for medical aid (emergency or otherwise), and sanitary assistance.
Civil Defense	Quantitative Qualitative	Amount of service used for preventive actions, emergency assistance and disaster response.
Economy	Qualitative	Level of influence on the economic activities in Rio de Janeiro, in the transportation, tourism, industry, commerce, safety and health segments.
Security	Qualitative	Amount of service used to meet the needs of the Ministry of Justice and Defense, and the Public Security Bureau, among others.

Table 3 Aspects assessed in the 2007 Pan-American Games

4.4 Defining severity levels

Severity is defined in three levels: high, medium, and low. The influence of each service on each aspect assessed is taken into account. The analysis of these levels contextualizes the aspects defined in Stage 2 with the specified severity levels. Table 4 shows the results for some of the aspects used by MI²C during the 2007 Pan-American Games.

4.5 Defining aspect weight

Weights are assigned to each aspect so they can be qualified. Weights are important and can be modified according to the context of each country, because the importance of each aspect will vary from place to place. In the case of the Pan-American Games, due to the stability of the country's economy, no single aspect was considered more important than the others. Therefore, the same weight was assigned to each one of the aspects. Table 5 illustrates these weights.

4.6 Assessing severity levels

During this stage, the severity levels specified in Stage 3 are associated with previously identified services. It is possible to identify the relationship of each analyzed service (Stage 1) and its level of importance for the aspects defined in Stage 2, considering the weights specified in Stage 4. This relationship is illustrated in Table 6. In this example, Service 1 presents a high severity level in all aspects analyzed.

4.7 Specifying and prioritizing critical telecommunication services

During this phase, telecommunications and broadcasting services are prioritized. The previously defined qualitative severity levels are converted to quantitative values. The following values are assigned to the severity levels – Low = 1 (one); Medium = 2 (two); High = 3 (three). The most critical services are those with the highest end sums.

4.8 Identifying the network infrastructure

The final result of this stage will be a database with all the information provided by the service providers, analyzed, organized and prioritized to provide a clear picture of Brazil's critical telecommunications infrastructure in preparation for the following phase of MI²C.

All the providers of telecommunications services identified as critical in Stage 6 are selected to supply this data.

		Aspect					
		Scope	Population Serviced	Publicity	Social & Cultural	Health & Emergency	Civil Defense
Criteria	High	Over 85%	Over 80%	Use directly	Important and necessary	Essential	Essential for operation
	Medium	Between 40% and 85%	Between 50% and 80%	Use indirectly	Useful and helpful	Useful and helpful	Used for reporting the problem
	Low	Under 40%	Under 50%	Not used	Not used	Not used	Not used

Table 4 Severity levels

	Aspect					
	Scope	Population Serviced	Publicity	Social & Cultural	Health & Emergency	Defense
Weights	**1**	**1**	**1**	**1**	**1**	**1**

Table 5 Aspect weight

Aspects & Criteria		Coverage	Population Serviced	Publicity	Social & Cultural	Health & Emergency	Defense
Weights		1	1	1	1	1	1
Services	# 1	High	Medium	Medium	Low	Medium	High
	# 2	High	High	Medium	Medium	Low	Low
	# ...	...	...	...	...	...	...
	# *n*	High	High	High	Medium	Low	High

Table 6 Severity level versus aspects

The telecommunications station was chosen to be the common element among the various telecommunications infrastructures since it aggregates several kinds of services and technological resources. This allows the infrastructures to be compared and prioritized. This classification is based on technological criteria, some of which are shown in Table 7.

Technological criteria
Interconnection point
Local / International traffic
Function / Topology
Type of backbone
Management system
Satellite (type and function)

Table 7 Technological criteria

Technological criteria are organized in information sets called categories, which help define the station's priorities.

Besides the technological criteria, other aspects are taken into consideration, such as areas with high concentrations of infrastructure, or areas of strategic importance, such as border regions and military areas, among others. This classification has been called strategic/geographic criteria, as illustrated in Table 8.

	Cities and Capitals (> 200T habitants)
Strategic points and Security areas	Health sector (hospitals and treatment centers) Public security (fireman, police) Government sector (state, federal and local) Financial sector (banks, stock market) Transport sector (port, airport) Energy sector (power generator, oil refineries, hydropower) Industrial sector (siderurgic, chemical, petroleum)

Table 8 Strategic/geographic criteria

In the 2007 Pan-American Games in Rio de Janeiro's case study, data from the telecommunications networks used by the service providers in the city of Rio de Janeiro were collected. The following information was utilized:

- Current and estimated traffic for Pan 2007
- Physical location of equipment
- Current and estimated future central office telephone switches
- Topology and network capacity
- Interconnection points with other critical service providers
- Contingency strategies (current and for Pan 2007)
- Points identified as critical
- Capacity and occupancy per service of the basic networks (terrestrial, satellite and underwater terrestrial cable networks)
- Location, facilities and operating schedule of each service’s supervision units

Based on this information, it was possible to identify the network infrastructure that would support critical services during the 2007 Pan-American Games, consisting of approximately 70 sites and networks. As illustrated in Figure 9, the network infrastructure and services considered critical make up what is called the critical telecommunications network.

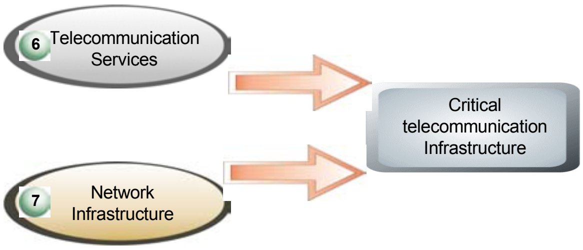
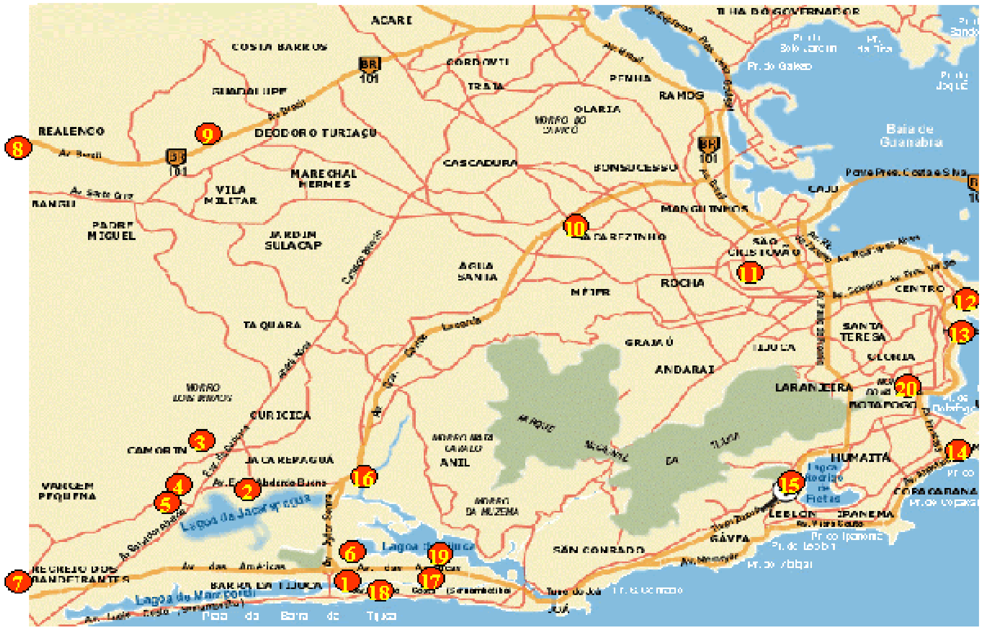


Figure 9 Critical Telecommunications Network

The assessment of the critical telecommunications infrastructure for the 2007 Pan-American Games began with identifying the geographic locations of the telecommunications logistics and support centers and the main sites where the games were going to be held, as illustrated in Figure 10.



1 Marapendi Country Club
2 Complexo Esportivo do Autódromo
3 Morro do Outeiro
4 Complexo Esportivo Riocentro (IBC/MPC)
5 Complexo Esportivo Cidade do Rock
6 Centro de Boliche Barra
7 Centro de Futebol Zico
8 Complexo Esportivo Miécimo da Silva
9 Complexo Esportivo Deodoro
10 Complexo Esportivo João Havelange
11 Complexo Esportivo do Maracanã
12 Marina da Glória
13 Parque do Flamengo
14 Praia de Copacabana
15 Lagoa Rodrigo de Freitas
16 Vila Pan-americana
17 CO Rio
18 Hotel Oficial - Windsor da Barra
19 Tech. Operarion Center- Shopping Citá America
20 MOC- Main Operation Center - Oi/Telemar

Figure 10 2007 Pan-American Game Sites

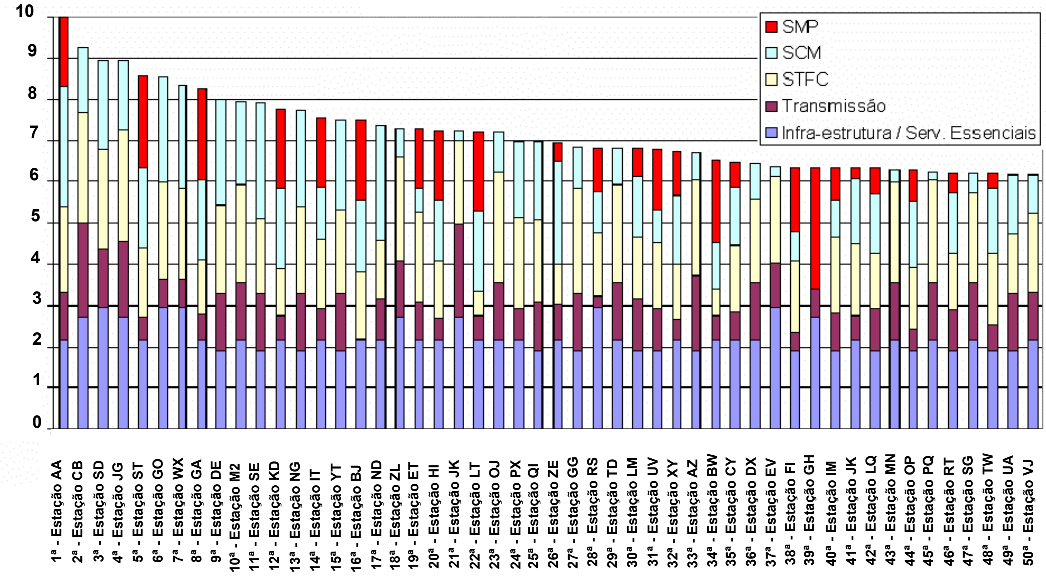


Figure 11 MI^{2}C methodology used to rank telecommunication stations

4.9 SPECIFYING AND PRIORITIZING CRITICAL TELECOMMUNICATION INFRASTRUCTURE ELEMENTS

In this phase, the telecommunications stations are prioritized according to their rank of importance and/or severity. It is possible, for example, to map all the stations in the vicinity of flooded areas as in the Itajaí Valley in November 2008, when several cities suffered service interruption. In the 2014 World Cup, the same kind of analysis can be applied. The system will be able to select only the cities that will host the games.

As illustrated in Figure 11, the final result of this stage will be a list of analyzed, organized and prioritized telecommunications infrastructure assets, thus providing a clear picture of Brazil's critical telecommunications within the analyzed context.

Observe that the highest-ranking station, Estação AA, provides three services (STFC, SMP and SCM), and the three next stations (CB, SD and JD) do not offer mobile services. This demonstrates MI^{2}C's flexibility, with an in-depth analysis of how each category's grade affects the final rank of the station. For instance, if PSTM were the main focus of the analysis, Station CB would achieve the highest score.

This can also be accomplished by using a layer model, like the one used in the 2007 Pan-American Games (Figure 12), allowing the critical infrastructure to be evaluated according to elements such as critical services, switching, transmission and network infrastructure.

Considering all the available information, and the level model shown in Figure 12, 25 evaluation criteria were selected and grouped into six categories: "Game Sites," "Infrastructure," "Transmission," "STFC", "SCM" and "Mobile Services" (which includes both SMP and SME), as illustrated in Figure 13.

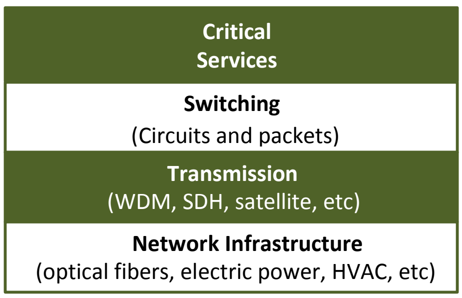


Figure 12 Layer model

Once the categories had been evaluated and the criteria defined, the most critical stations for the 2007 Pan-American Games were prioritized, as illustrated in Figure 14.

The most critical elements can be organized in a different way, as seen in Figure 15.

Prioritizing critical infrastructure elements provides a clearer view of critical points that affect available telecommunications services, and also shows the interdependence among different services. The prioritized elements are thus given more attention to ensure the availability and continuity of services.

Threat assessment, the use of ideal scenarios, and interdependency analysis are all based on MI^{2}C results, and are part of the CTIP project.

Categories	Criteria				
Pan2007 sites	Venues		Logistic and Telecom Support		
Telecom Infra	Shared wire center (station)	AC/DC Generator	Fiber concentration	NOC/SOC	PAN2007 access Network
Transmission	WDM	Local SDH	Long Distance SDH	Satellite	
Switching #1	MPLS	Local IP	International IP	ATM	Metro Ethernet
Switching #2	Signaling	Local Traffic Exchange	Local traffic Tandem	National LD Tandem	International LD Tandem
Switching #3	MSC/MGW	BSC	BTS		

Figure 13 Categories and respective criteria

Order	Telecom Provider	Station	Points
1	Provider_A	Stat_5	5,69
2	Provider_B	Stat_7	5,32
3	Provider_A	Stat_2	4,54
4	Provider_C	Stat_1	4,52
5	Provider_A	Stat_8	4,21
6	Provider_A	Stat_9	3,86
7	Provider_D	Stat_6	3,82
8	Provider_B	Stat_3	3,45
9	Provider_B	Stat_4	3,45
10	Provider_A	Stat_10	3,44

Figure 14 Prioritization of critical infrastructure elements

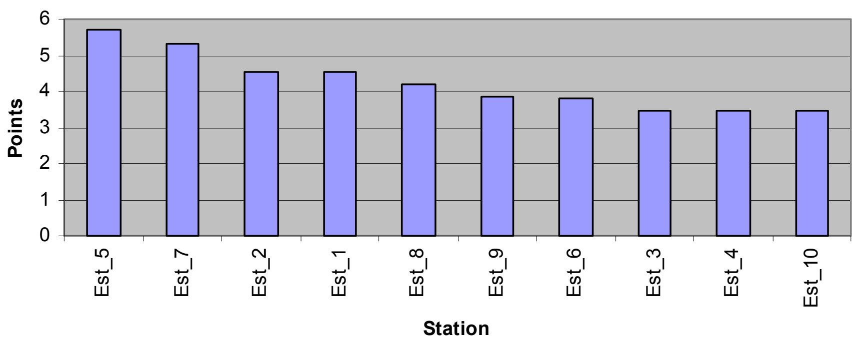


Figure 15 Ranking and Prioritization of critical infrastructure elements

As can be seen, MI²C results are useful for telecommunications network planning, especially in the context of major sporting events like the 2014 World Cup and the 2016 Olympic Games. In fact, the CTIP Project will be used not only to define critical telecommunications services in these two upcoming events in Brazil[35] but also to provide a risk analysis and generate an action plan to guarantee the success of the events.

4.10 CASE STUDY RESULTS

In the Pan-American games only the first methodology was applied and tested. The objective at that time was identifying the most important assets related to the scope of the event.

However, with the results provided by MI²C, it was possible to implement some extra controls at the planning phase, in which the main objective was to guarantee the continuity of the services during the games, especially with measures to prevent vandalism in high-risk areas. These controls (at this phase, physical ones) were implemented in agreement with the federal government and private sector (telecommunications providers).

No serious problems were experienced during the events. While there were ordinary issues such as hardware problems, they did not disrupt service.

5 MOBILKOM AUSTRIA – CASE STUDY

The greatest challenge in studying the past experience of major sporting events, as well as the way mobile networks behave during these events, is that most mobile operators are reluctant to make their experience public. One exception is mobilkom austria, the leading mobile operator in Austria, a country that hosted the UEFA Cup of 2008 (European Football Championship) together with Switzerland. In preparation for the event, mobilkom austria endeavored to update its network to provide its users and roaming visitors with the best possible services.

The Austrian operator’s experience with HSPA networks is especially relevant to Brazil as it plans for the 2014 World Cup. In 2006 in Germany, mobile networks with 3G HSPA were not yet widely deployed. However, during the UEFA Cup of 2008, mobilkom austria’s HSPA networks were both operational and mature. Across Europe, HSPA had become widespread in the European handset base, and millions of USB modems and embedded devices had become the standard for laptops.

The contribution of mobilkom austria to this study offers important insights into how mobile companies prepare for major events and also how users utilize the network on these occasions.

5.1 TRAFFIC VARIATIONS

As observed in other sporting events and cited above in the case of Germany, the biggest traffic changes in mobilkom austria’s network occurred at event venues, both in Fan Fests and in stadiums and media centers, where journalists and other media professionals cover the events. Additionally, team hotels and press conference areas for the top teams had to be taken into account in planning coverage as well as capacity. In the rest of the network no significant change in the overall traffic was observed during the tournament.

In order to handle the increased traffic, multiple carriers decided to deploy and share telecom infrastructure in the stadiums, while at the Fan Fests operators chose to increase network capacity through independent mobile sites placed in vans. mobilkom austria made most of the fixed investments with a view to the future, using the event to continue strengthening its network. Both traffic and signaling resources are critical factors in capacity planning. In particular, SDCCH (Stand-alone Dedicated Control Channel) resources for SMS have to be dimensioned properly.

City	Stadium	EM capacity	number of matches	comment
Vienna	Happelstadion	50.000	7	3 Matches Group B 2xquarterfinal 1xsemifinal EM Finale
Salzburg	Wals-Siezenheim	30.000	3	3 Matches Group D
Innsbruck	Tivoli-Neu	30.000	3	3 Matches Group D
Klagenfurt	Wörthersee	30.000	3	3 Matches Group B

Host City	Fan Zone Location	Capacity (max. number of spectators)
Vienna	Rathausplatz, Heldenplatz, Ring	70.000
Salzburg	Mozartplatz, Kapitelplatz	25.000
Innsbruck	Bergisel (Sprungschanze)	15.000
Klagenfurt	Messegelände, Neuer Platz	28.000

Table 9 Euro 2008 cities, stadiums and capacities.

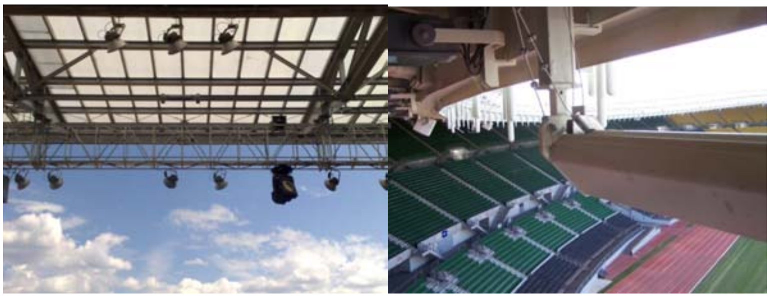


Figure 16 Antenna locations on stadium roofs

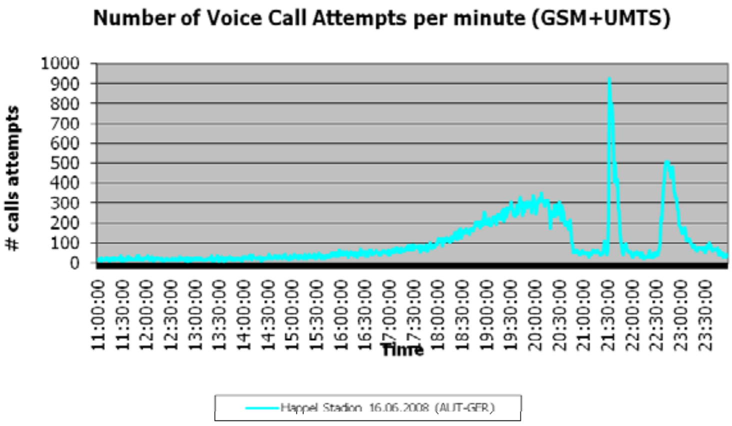


Figure 17 Distribution of number of voice call attempts per minute in Happel Stadium in Vienna

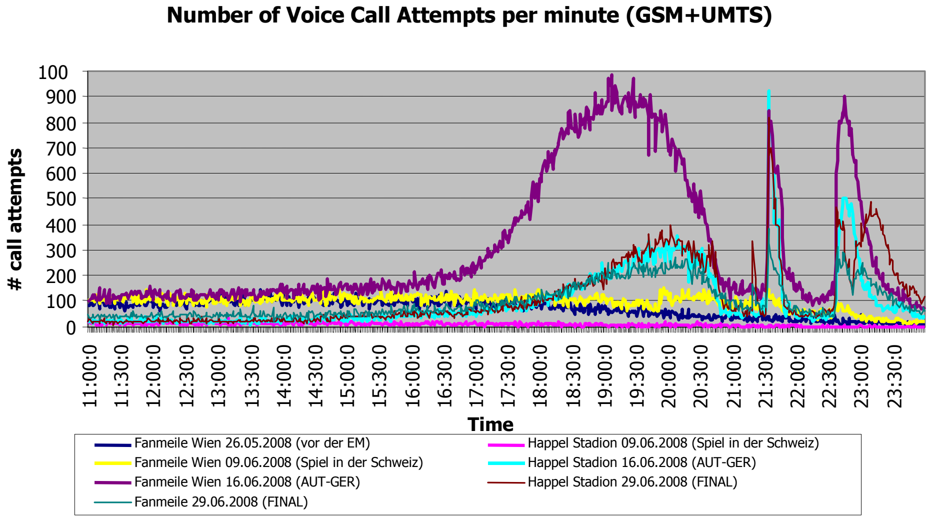


Figure 18 Distribution of number of voice call attempts per minute during the Fan Zone in Austria

Moreover, it is worth mentioning that mobilkom austria is a network operator that is acquainted with handling large fluctuations in network traffic volume during sporting events such as ski races and events like the Hahnenkamm Races in Kitzbühel that occur in winter seasons on the ski slopes of Austria, where many tourists from across Europe and around the world visit and roam onto mobilkom austria's network. Network operators in Europe are used to roaming users from other European countries. This reality in the EU leads to a more competitive fares for roaming services.

As an example, a user of post-paid services visiting Austria from the Netherlands in July 2008 paid between €1.76 and €2.32 to make a call of four minutes (at peak time) to his home country. To receive a call from the Netherlands, prices ranged from €0.88 to €1.16 for roaming services. In this example, the variation in rates is related to agreements between different European network operators. With the tariff reduction of July 2009[36,] these prices had decreased further since then.

By comparison, in 2010 a post-paid user of O2 in Brazil pays between £1.70 (€1.87) and £1.41 (€1.55) per minute to make or receive a call to or from London at base rates. This same user traveling to Austria would pay between £0.35 (€0.39) and £0.18 (€0.20) for the same call[37].

5.2 Roaming

It was also observed that in event venues, a significant variation in the number of calls was due to roaming users. In the case of stadiums, up to 70% of all calls were originated or received by roaming users depending on the teams playing, while in the Fan Fests this fraction reached a maximum of approximately 20%.

Besides being used to dealing with fluctuations in traffic on its network, mobilkom austria was prepared to handle a significant number of roaming users from other European operators during the 2008 UEFA Euro Cup.

5.3 Services

In the specific case of UEFA's event, mobilkom austria identified that the increase in traffic was a result of the use of voice services, with two-thirds of that traffic being carried over the GSM network and one-third over the 3G network (HSPA). In Austria as a whole, SMS, MMS and streaming video services did not experience a significant increase in traffic volume during the event, but did reach high peaks in stadiums and at Fan Fests.

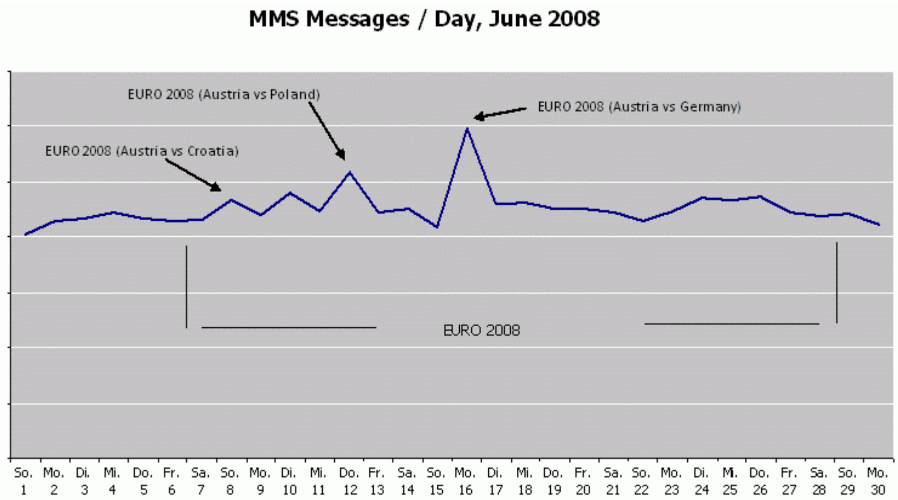


Figure 19 Distribution of MMS across the entire mobilkom austria network during the UEFA EURO 2008

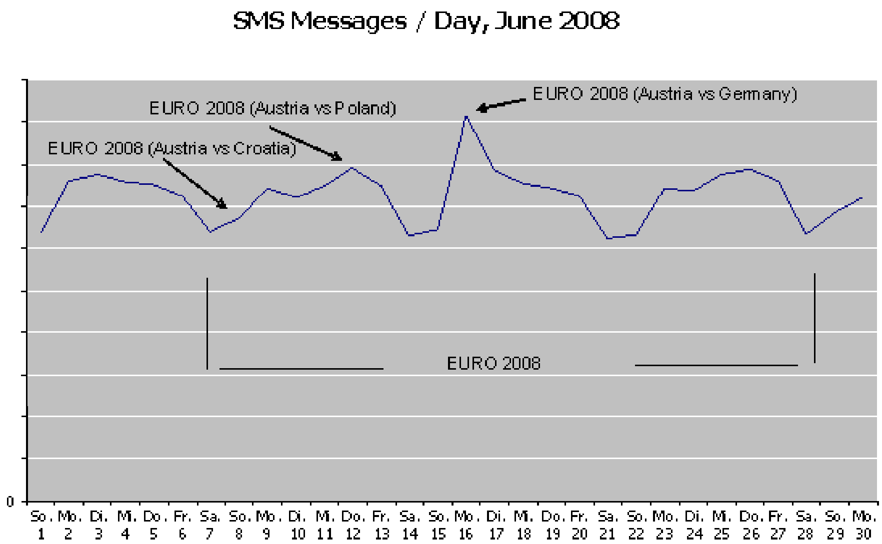


Figure 20 Distribution of SMS across the entire mobilkom austria network during the UEFA EURO 2008.

Regarding media centers, even with the extensive WLAN infrastructure deployed by UEFA, it was found that a large number of media professionals covering the event carried devices such as data cards and USB modems to access mobilkom austria's 3G network. A huge volume of data traffic came from the media centers.

A digital mobile TV service based on the DVB-H transmission technology was implemented at the time for the UEFA Euro 2008, but the demand proved to be relatively low. Therefore, mobilkom austria has been rethinking its model for video/TV for the future, by refocusing on video streaming, live streaming TV and content downloads on demand.

5.4 Risk Management and Protection of Critical Infrastructure

For the event, UEFA instructed telecom operators to follow its plans, recommendations and best practices strictly. These plans comprised several topics related to business continuity, risk management and general security and safety issues – from information security to physical safety. Moreover, audit procedures were under the responsibility of UEFA, which also coordinated security along with the local government.

It is suggested to use uninterrupted power supply (or UPS) wherever possible as well as redundant backhaul facilities, at least for the most important sites. Access to spare parts could also be a critical issue, since access to some sites is limited due to security reasons.

In preparation for the Olympic Games and Para-Pan American Games, the International Olympic Committee (IOC) provided a "book of practices" for information security. Similarly, for the 2014 World Cup and the 2016 Olympic Games, as disclosed in the application file, Brazil should implement a CTIP project (Critical Telecommunications Infrastructure Protection Project). In addition, FIFA should also provide a "book of best practices" for the event.

6 2014 TRENDS

6.1 MOBILE TECHNOLOGY IN 2014

Mobile broadband forecasts indicate that in the coming years, the most widely used technologies in the world will be HSPA/HSPA+ and LTE, as illustrated in Figure 21.

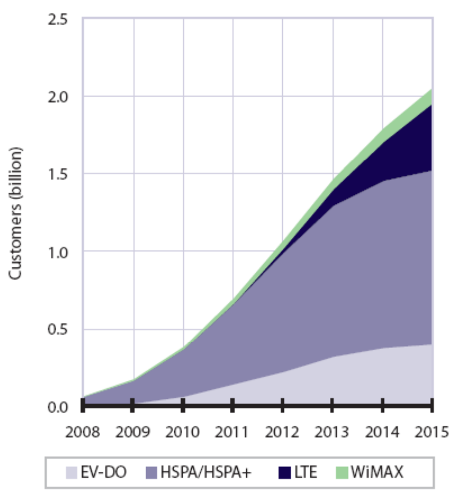


Figure 21 Worldwide broadband user forecast, by technology (Source: Analysys Mason)

HSPA/HSPA+ and LTE evolved from the GSM family and are 3GPP standardized. EV-DO is an offspring of IS-95 and CDMA-2000, and is standardized by 3GPP2. IEEE is responsible for standardizing WiMAX systems.

1) HSPA (High-Speed Packet Access) and HSPA+

HSPA, which includes HSDPA (High Speed Downlink Packet Access) and HSUPA (High Speed Uplink Packet Access), is the first step in WCDMA evolution.

Claiming to offer data transmission rates ranging from 1.8 Mbps to 14.4 Mbps, HSPA supports bandwidth-hungry applications. The higher data transmission capacity of HSPA compared to WCDMA is related to the use of several modulation and data-processing techniques.

HSPA+, or HSPA Evolution, uses multi-beam transmission and other new characteristics that, added together, improve the system's performance significantly. HSPA+ theoretically offers transmission rates that range from 11 Mbps to 84 Mbps, depending on the techniques used.

Figure 22 shows the evolution of WCDMA and HSPA technology.

2) LTE (Long-Term Evolution)

LTE introduces new radio communication technology with even greater spectral efficiency, offering from two to four times more capacity than HSPA systems. Better spectral efficiency allows higher bit rates on the same frequency band.

This technology delivers peak downlink (DL) and uplink (UL) rates of up to 100 Mbps and 50 Mbps respectively. Associated with other techniques, these peak rates can be even greater. LTE evolution is illustrated in Figure 23.

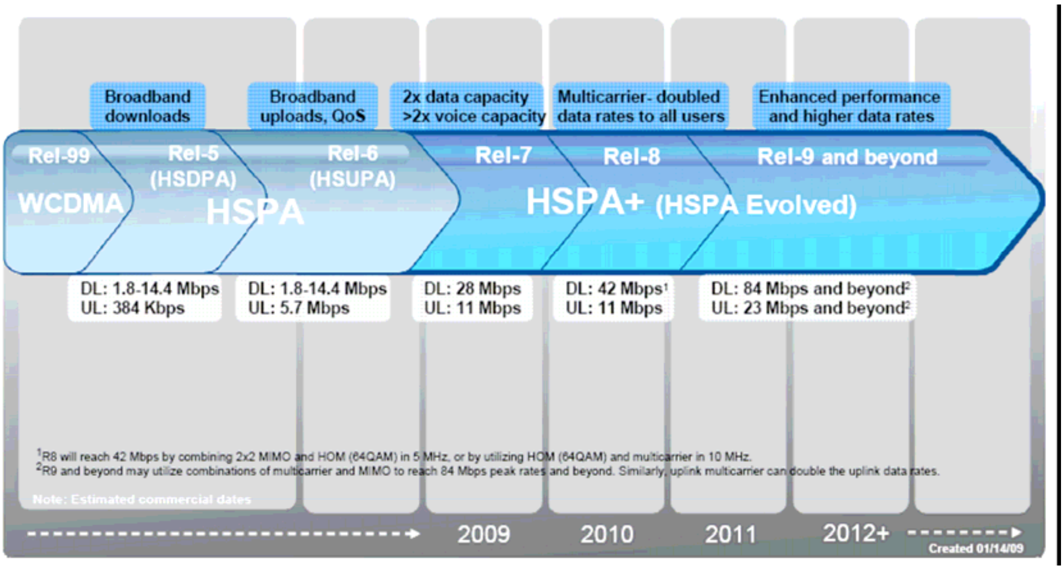


Figure 22 Evolution of WCDMA and HSPA technology (Source: Qualcomm)

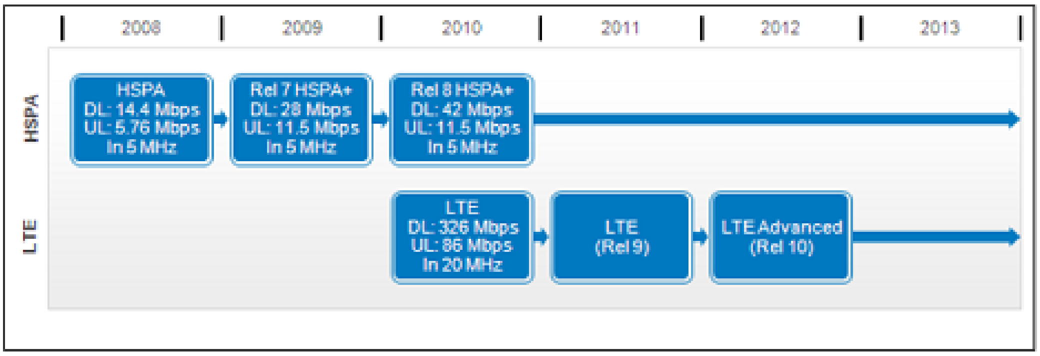


Figure 23 LTE Evolution (Source: 3G Américas)

3) EVDO

While HSPA and LTE evolved from 3GPP standards, EVDO (Evolution Data Optimized) originated from CDMA 2000 cell phone systems and is standardized by 3GPP2.

Part of the Brazilian network is still EVDO-based, but the trend is for it to be supplanted by HSPA, LTE and possibly WiMAX systems by 2014.

4) Digital and Mobile TV

Several commercially tested digital TV technologies are currently available and will likely become mainstream technologies by 2014. The European DVB-H (Digital Video Broadcasting-Handheld), the South-Korean T-DMB (Digital Multimedia Broadcasting), the North American FLO (Forward Link Only), the Japanese ISDB-T (Integrated Services Digital Broadcasting), and others like DAB-IP (Digital Audio Broadcasting) and MBMS (Multimedia Broadcast Multicast Service) for IP Datacast are competing for this market. After a series of risk analysis studies and standard adaptations for country-specific characteristics, Brazil chose ISDB-T in 2006.

The introduction of digital terrestrial TV in Brazil a little over two years ago opened up new opportunities for digital mobile TV services. TV is a very familiar means of communication for Brazilians. Almost 95% of the nation’s homes have televisions, a total of 53 million families. The Brazilians' passion for TV, along with the widespread adoption of cell phone technology, is a factor that boosts the country’s great potential for mobile TV. At the end of 2009, the number of cell phones in the country hit the 174 million mark, with a density of 90.6 devices per 100 inhabitants. In addition, according to research, the mobile handset and the TV set are the two most important items in the average Brazilian’s everyday routine. Around 77% of those polled named TV as the most important means of communication, while approximately 70% chose the cell phone[38]. Computers with Internet access ranked only in third place, with 58% of the answers.

Watching videos is also a very widespread habit in Brazil, especially among the younger generation. Web-based services such as YouTube, mobile video services based on real-time streaming and downloads, and user-generated content (videos produced by users on their cell phones) have all contributed to make videos increasingly popular. The growing popularity of analog mobile TV will no doubt stimulate the habit of watching TV on cell phones. According to another poll[39], more than half of analog mobile TV owners watch television for over half an hour a day. Roughly 18% of the users watch TV daily, and 10% tune in five days a week.

Given the familiarity of Brazilian consumers with TV and the cell phone, the combination of these two means of communication to create value-added services appears less challenging than for other forms of mobile entertainment. However, there are several aspects that need to be honed for digital terrestrial TV to become more widespread.

The digital terrestrial TV standard adopted by Brazil in 2006, Integrated Services Digital Broadcasting – Terrestrial (ISDB-T), was designed from the ground up for mobile and portable reception. The frequency band is segmented into 13 sub-bands of 429 MHz and only the central segment is allocated for simultaneous transmission of multimedia services for mobile devices (one seg) and fixed Direct TV (DTV) services. A Single Frequency Network (SFN) can be configured with 12 segments dedicated exclusively to mobile terminals (ISDB-Tn). Transmitting an HDTV channel and a mobile TV channel within the same bandwidth is a major benefit compared to other digital TV standards, such as DVB-H and Media FLO, for example, which need additional spectrum for mobile transmission. DVB-H and Media FLO-based services usually work like subscription television for the cell phone, with carriers charging their users monthly fees[40]. Brazilian broadcasting legislation stipulates that digital mobile TV must be free of charge on the frequency band allocated to terrestrial digital broadcasting[41] and its program content must be identical to that of fixed TV[42]. However, offering the same program content for mobile devices might not be very attractive to users. The format and kind of content are essential factors for the success of mobile TV. Broadcasters and cell phone carriers and manufacturers must take into consideration consumers' mobile TV experience, analyzing usability factors such as screen size, places and situations where they watch TV, and time of exposure to the media, and offer business models accordingly.

They must seek answers to the following questions: Will mobile TV compete with traditional TV? Will there be complementary program content? Will the programs be shorter than those of traditional TV? How fundamental is interactivity? Will the use of mobile TV reduce the use of the cell phone for calls and other mobile services, such as SMS and data transmission? Services that explore interactivity and a hybrid business model that combines open and subscription TV (via real-time video streaming and downloads) can increase mobile TV’s appeal. Furthermore, a hybrid business model based on interactivity can make digital terrestrial mobile TV economically feasible for mobile carriers. This is the trend in Japan, where commercial agreements have been made between free-to-air terrestrial TV providers and mobile carriers.

As for interactivity, Brazilian digital TV program content has yet to explore this functionality. The first cell phone models equipped with digital terrestrial TV receivers were sold in Brazil in 2008 but do not have this feature[43]. Nevertheless, by 2014, business models and interactive services will certainly be thoroughly developed and exploited, as long as the different players in this segment cooperate. Carriers, broadcasters and manufacturers have four years to try out different kinds of services and satisfy users' desires and needs. It's important to point out that the price of mobile data traffic must be adjusted for interactivity to be economically feasible.

Another aspect that can hinder widespread use of digital terrestrial mobile TV is the cost of terminals. There are currently few cell phone models equipped with digital terrestrial TV receivers available on the market, and the cost is not affordable to most of the population. Usually only high-end cell phone models are equipped with digital TV technology. To encourage the dissemination of mobile TV, the integration of digital terrestrial TV signal receivers must quickly be extended to include a greater variety of cell phone models, and not only high-end models.

The pace of this integration will depend in great part on successful commercial agreements between equipment manufacturers, mobile carriers and open-TV broadcasters. With the proper commercial incentives, the carriers can offer devices at subsidized prices to their subscribers. The issue of subsidized prices for cell phones with digital terrestrial TV receivers might face a certain amount of resistance from Brazilian carriers in the beginning. Business models involving broadcasting and cell services have not yet been defined, and there is no assurance that they are win-win propositions. Mobile carriers may legitimately think that the time users spend watching TV on their cell phones will mean less time spent on revenue-generating calls. However, interactive services associated with TV programming content can be another major source of income, since they will stimulate the use of data services.

Digital mobile TV penetration will also depend on the range of digital terrestrial transmission coverage. A little more than two years after the first digital terrestrial TV transmission in the country, almost 2 million receivers (including set-top boxes, TVs, portable devices and cell phones) were sold. Currently, over 60 million Brazilians have access to digital TV, with 27 cities, 19 of which are capital cities, covered. Ingredients such as cheaper receivers, the expansion of digital TV coverage and the launch of interactive services are expected to boost the popularity of the new technology. Another ingredient that can greatly stimulate the growth of digital TV in the country is the large market that is beginning to form in Latin America, as Argentina, Chile, Peru and Venezuela have all adopted the ISDB-T standard. Other potential users include people in countries like Bolivia, Paraguay and Ecuador, representing a market of over 300 million potential users. By the time of the 2014 World Cup, the analog signal switch-off in Brazil will be two years away, and Brazil as well as the other countries in Latin America will have broad digital terrestrial TV coverage.

5) WiMAX

WiMAX (Worldwide Interoperability for Microwave Access), a wireless broadband system standardized by IEEE, is a high-speed data alternative that coexists in the market with HSPA and LTE networks.

WiMAX can theoretically deliver peak rates of 70 Mbps. In practice, its rates are very similar to HSPA, varying according to the allocated bandwidth and modulation techniques.

Embratel currently operates a 3.5 GHz WiMAX network in Brazil, servicing approximately 300 cities with fixed broadband services of up to 2 Mbps[44].

6.2 SERVICES IN 2014

A gradual increase in data service access is expected through 2014. Besides the traditional voice and SMS traffic, there will be an increase in SMS traffic associated with applications and sponsorships during the event. The applications that generate most SMS traffic for Brazilian providers are related to information channel subscriptions (news, alerts, etc.)[45].

But until 2008 Brazilians still had a small SMS adoption, with an estimated 11 SMS/mobile/ month on average. This ranks very low when compared with 388 for United States users or even 37 for Latin American users.[46] The numbers get better when you restrict the mobile subscriber sample to three of the big urban areas (São Paulo, Rio de Janeiro and Porto Alegre), where the average is 39 SMS/mobile/month.

These numbers are in accordance with other data showing that from 2005 through 2008 the fraction of mobile subscribers who utilize SMS (sending or receiving) grew to 55% from 42%, showing a slow adoption process or even saturation at levels lower than 100%.[47]

The same market research from NIC.br (Núcleo de Informação e Coordenação do Ponto BR) shows a different trend for sending/receiving photos and/or images, which grew to 24% from 9% in the same period.

Furthermore, according to Deutsche Telekom Group's 2006 fiscal year report, during the FIFA World Cup 2006™ the total data volume transmitted via T-Mobile's network during the sporting event in Germany was significantly greater than in previous months. In fact, 11% more SMS messages and 18% more MMS messages were sent via the T-Mobile network compared to the usual daily figures.[48]

These are numbers to think about when you are planning an event like a FIFA World Cup because you probably have a network dimensioned for low SMS and MMS traffic figures (average and fluctuations) when compared with other countries as a function of the local subscriber base behavior. Another consideration is the difference in data usage of SMS/mobile/month from different regions of the host country. As a result, high demands on the host cities' networks can come not just from international fans, but also Brazilian fans coming from different regions of the country with more propensities for SMS usage.

Besides SMS and MMS, new data services likely to expand by 2014 with 3G technology are:

- Mobile Advertising
- Mobile TV
- And, the most important, Mobile Social Networking

Mobile Advertising probably will add moderate traffic over SMS and MMS, according to advertising business models. Anyway, it is possible that the numbers pointed above for the traffic growth in 2006 in Germany serve as a warn to Brazilian operators.

We expect the expansion of Mobile TV in Brazil to concentrate on free-to-air broadcasting as result of the adoption of the ISDB-T standard[49]. Despite the adoption of ISDB-T almost four years ago, and the launch of fixed digital terrestrial TV transmissions almost two years ago, the players have only now started implementing the necessary middleware to permit interactivity, consequently bringing mobile operators into the value chain as a return channel provider[50]. So, we have two possibilities for the 2014 mobile scenario: the best-case scenario was pointed out in the previous section, with players having four years to achieve agreements and launching mobile TV with interactivity; and, in the worst-case scenario, the necessary agreements between broadcasters and mobile operators over the business models, revenue sharing and practical steps to implement and test interactivity services would not be achieved in the next four years.

The second option – of no agreement between mobile operators and broadcasters – is likely. As a result, Mobile TV and Mobile Services during the 2014 World Cup will just share the same device but stay in separate ecosystems (TV and telecom). In an intermediate scenario, both sectors would share revenues based upon the old business models for TV show promotions based on SMS. There would be no impact on local network traffic – because mobile broadcast DTV runs on different spectrum bands. It must be remembered that abroad fans with DVB-H (mostly Europeans), T-DMB or FLO (South Koreans, North-Americans, etc) integrated on WCDMA/HSPA or LTE handsets will not be able to get access to these broadcast images.

We believe that Mobile Social Networking, not just fixed Internet access to Social Networks, will be the most important mobile data service by 2014. This is a mobile data service definition more specific to the mobile ecosystem, looking at the importance of context on the mobile services offered (location-based services, m-payment, enhanced mobile communications services, etc.)[51].

One reason to believe on the success of Mobile Social Networking is that, unlike the uptake of SMS, Brazilian Internet users have adopted social networks to a deeper degree than in many other countries, as can be seen in the research conducted by Nielsen in 2008, and presented in Figure 24.IBOPE, the Brazilian Institute of Public Opinion and Statistics, a Brazilian multinational specialized in media, market and opinion research, collected the Brazil data as a partner of Nielsen. The data pointed out that users spend by far more time on social networks than any other Internet application[52]. This behavior may have a huge impact on network traffic by 2014, which will demand more frequency bandwidth, network infrastructure optimization and contingency planning to guarantee the availability and quality of service.

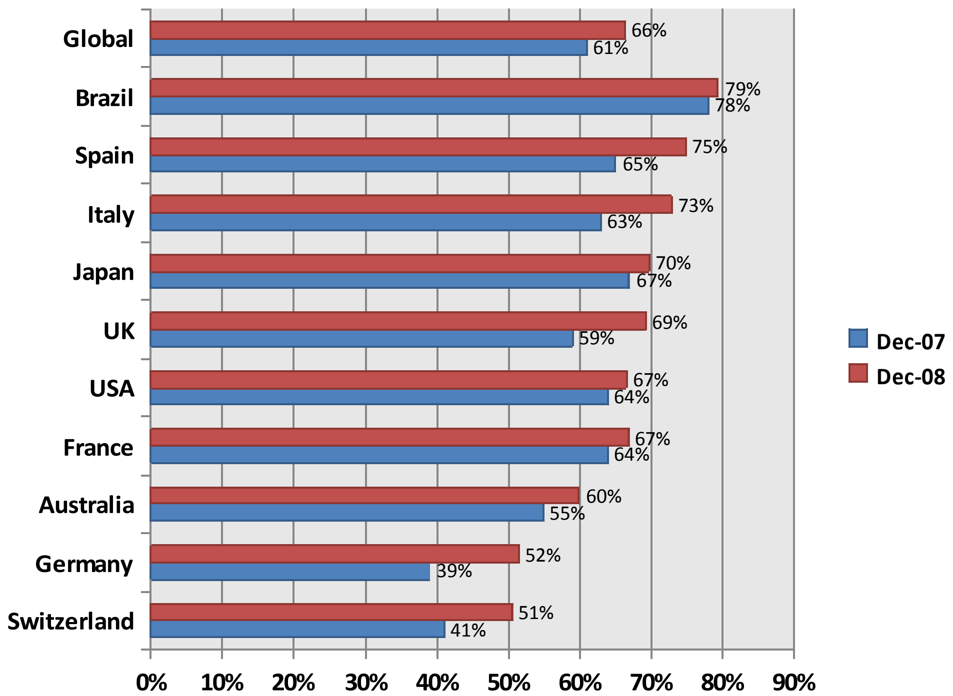


Figure 24 Penetration of social networks among Internet users[53]

Last but not least, because this is a worldwide sporting event and performed in a number of cities that will receive many foreign visitors, roaming is a service that should be considered carefully.

- *Roaming*

The following chart shows the 12 cities that will host World Cup games in Brazil, their population and number of subscribers per service code, since these large urban centers go beyond the area of the host cities. Notice that only six of the cities have an EVDO network for visitors from countries that have adopted this technology, and the mobile operator with dual operation of EVDO/WCDMA has plans to shut down this technology soon. Visitors must be advised ahead of time about available roaming partnerships and the need to rent functional terminals. All the major carriers are present in the 12 cities, but certain tourist centers (in particular, beaches) may not have 3G coverage by 2014.

Statistics from the German 2006 World Cup reveal that FIFA Fan Fests drew a total of 21 million people, and that the host city of Berlin alone, with a population of 3.4 million, attracted 9 million participants. That was the first time an event in Germany received more visitors than the Oktoberfest[54]. That should give us a sense of what could happen in Brazil during the 2014 Fan Fests.

6.3 DEMAND FORECAST AND TRAFFIC ESTIMATES

By all indications, the Brazilian cell phone system will be based on HSPA and LTE technology in 2014. HSPA and LTE are evolved WCDMA systems, and follow 3GPP standards. Their main feature is their data transmission rates.

According to 3GPP specifications (Figure 22), the data transmission rates are the following:

- HSPA: 14 Mbps DL, 5.8 Mbps UL
- HSPA+: 42 Mbps DL, 11 Mbps UL
- LTE 100 Mbps DL, 50 Mbps UL

These transmission rates represent the approximate maximum rate a base transceiver station sector can deliver to the area it services.

It is possible to run simulations to determine the approximate rate these technologies would deliver under real working conditions. Simulations were performed[55] to determine the service capacity of HSPA and LTE 3G cellular phone systems under different traffic conditions. The area consisted of 19 sites (three sectors per site), with a radius of 167 meters and 10 active users per sector. In the case of an LTE system operating in a 2 X 5 MHz channel in an urban area, the average rate per user, with cell throughput at 8 Mbps, was approximately 2.5 Mbps. Under these conditions, maximum cell throughput was approximately 9 Mbps. For HSPA, under the same conditions, maximum cell throughput was approximately 8 Mbps. These are downlink rates; in other words, the data is flowing from the transceiver station to the terminal.

If it would be possible to allocate 2 X 20 MHz of bandwidth (current spectrum assignment practices in Brazil would have to change to do so), maximum cell throughput would reach 36 Mbps for LTE and 32 Mbps for HSPA.

It's important to highlight that cellular systems are subject to a great number of variables that can affect their performance, such as user velocity, distance from the base transceiver station, antenna characteristics and system parameters. The results may vary according to the adopted premises. The simulation considered the most common situations that the systems would have to handle.

During the 2014 World Cup, the most critical situation will very likely be covering the stadiums and their surroundings, where there will be a very high concentration of subscribers, most of whom will be heavy service users.

Sites	Population:	Area	PMS Subscribers	Service Providers	Technologies[56]
Belo Horizonte	2.450.066	31	7.705.761	Claro, Oi, TIM, Vivo	1x / GP / ED / WCD / HSP
Brasília	2.606.885	61	4.105.143	Claro, Oi, TIM, Vivo	1x / GP / ED / EVD / WCD / HSP
Cuiabá	548.468	67	2.542.205	Claro, Oi, TIM, Vivo	1x / GP / ED / WCD / HSP
Curitiba	1.852.696	41	3.663.642	Claro, Oi, TIM, Vivo	1x / GP / ED / EVD / WCD / HSP
Fortaleza	2.506.064	85	4.244.885	Claro, Oi, TIM, Vivo	GP / ED / WCD / HSP
Manaus	1.741.211	92	2.414.368	Claro, Oi, TIM, Vivo	1x / GP / ED / WCD / HSP
Natal	805.920	84	2.691.640	Claro, Oi, TIM, Vivo	GP / ED / WCD / HSP
Porto Alegre	1.434.891	51	6.063.409	Claro, Oi, TIM, Vivo	1x / GP / ED / EVD / WCD / HSP
Recife	1.560.376	81	6.318.668	Claro, Oi, TIM, Vivo	GP / ED / WCD / HSP
Rio de Janeiro	6.173.935	21	12.973.623	Claro, Oi, TIM, Vivo	1x / GP / ED/ EVD / WCD / HSP
Salvador	3.004.571	71	4.587.241	Claro, Oi, TIM, Vivo	1x / GP / ED/ EVD / WCD / HSP
São Paulo	1.018.161	11	25.471.494	Claro, Oi, TIM, Vivo	1x / GP / ED/ EVD / WCD / HSP

Table 10 The 12 host cities: populations, subscribers in the surrounding area, service providers and network access technologies[57].

In the simulation, the service area of each sector is approximately 85,000 m², about the same size of a soccer stadium. As an illustration, observe in Figure 25 the Cícero Pompeu de Toledo stadium, one of the stadiums that will host the 2014 World Cup matches in the city of São Paulo. The area in the figure is approximately 85,000 m².

Figure 25 Cícero Pompeu de Toledo Stadium in São Paulo city

Let's assume that user density in the vicinity of the stadiums is 1 user per 10 square meters, that the occupancy level is 10%, and that average traffic is 200 kbps. These numbers are reasonable estimates.

Thus, for the downlink we have:

- User density in stadium surroundings: 0.01 users/m²
- User occupancy during period: 10% of the time
- Average traffic needed by user when connected: 200 kbps

This demand represents traffic density of 200 bps/m² or 17 Mbps per cell area. Even considering that changing system parameters might possibly improve network performance, it is very unlikely that HSPA or LTE cells, with a 2 x 5 MHz bandwidth, will be able to meet this demand. However, a cell with a 2 x 20 MHz bandwidth would be able to handle this amount of traffic without a problem.

Even if LTE is deployed in regions with high traffic density, one must remember that many users still do not have LTE terminals. As a matter of fact, the forecast is that most terminals in 2014 will be HSPA (see Figure 21). Therefore, strategic planning for the coverage of these areas must consider the use of islands, with LTE coverage for greater capacity, within an HSPA-based system. This is the most natural approach for cell service providers to evolve their networks (Figure 26).

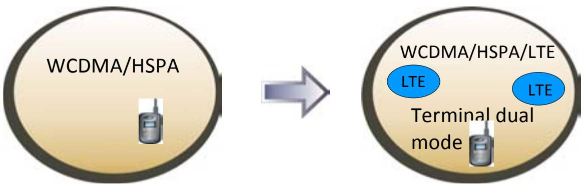


Figure 26 Strategy for implementing LTE islands within a WCDMA/HSPA area

An alternative way of increasing data transmission rates in areas of great user concentration, such as stadium surroundings, would be to increase the number of cells. This would, however, increase interference among the cells due to their proximity, causing system degradation and diminishing sector throughput. This coverage must be elaborately and meticulously planned out to minimize interference and reach the traffic capacity needed for the critical areas. Most likely, micro-cells will need to be set up in the stadiums to service areas with the greatest concentration of users, such as press rooms. In press rooms, LTE access will be essential and media professionals coming from abroad will bring LTE-enabled modems with them.

A factor that could circumvent the problem of interference between cells would be to broaden the frequency spectrum used by the system. The larger the frequency spectrum, the greater the capacity will be to support intense traffic demands. The presence of different operators will help lessen traffic pressure, since users will be divided among the various service providers in the area, each one using their respective frequency band. Depending on the location in Brazil, there could be up to four operators. This division of the traffic among service providers is a factor that must be taken into consideration.

6.4 Frequency Spectrum

The implementation of a cellular communication system involves a series of stages, from planning to completion. Significant time must be dedicated to the planning stage. All definitions that are necessary for its implementation, such as the available frequency spectrum, must be made well in advance.

The frequency bands for mobile communications in Brazil are distributed in the following manner:

- 850 MHz – A and B bands
- 900 MHz – extension bands for GSM
- 1700 MHz and 1800 MHz – D and E bands, and extension sub-bands for GSM
- 1900 MHz and 2100 MHz – reserved mainly for 3G

Figure 27 shows the frequency bands and their subdivisions.

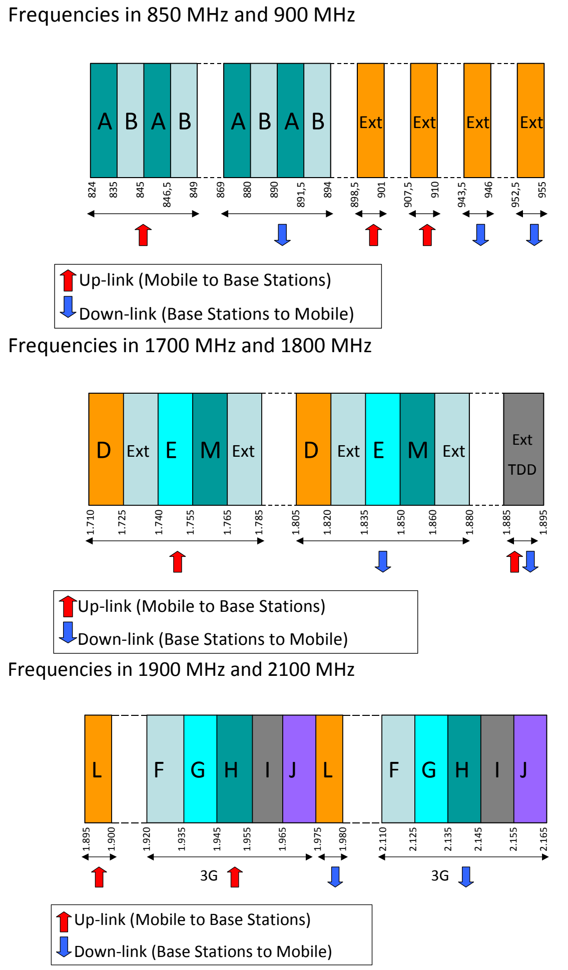


Figure 27 Frequency bands for mobile communication in Brazil

The frequency band destined for mobile services is sliced into relatively small pieces. The reason for this is to promote competition. Today, the total spectrum utilized by PMS (Personal Mobile Services)[58] in Brazil is approximately 300 MHz. A study carried out by the ITU (International Telecommunication Union)[59] estimates that in 2015, mobile telecommunications services will need over 1.0 GHz of spectrum to meet market demands.

To be able to offer higher traffic rates, larger spectrum bands would have to be allocated. There are several initiatives worldwide to allocate bands used by other services for mobile communications. In the World Radiocommunication Conference (WRC) held by the ITU in 2007 (a conference held every four years), a globally harmonized frequency spectrum was defined. This should be the reference for the expansion of spectrum for mobile services in Brazil. Following an ITU recommendation, in 2009 Anatel launched a public consulting project in order to define 140 MHz in additional spectrum to PMS in the 2.5 GHz band (2500 MHz to 2690 MHz). Dedicated to mobile data, this additional bandwidth will be crucial for mobile data transmission at both the 2014 World Cup and the 2016 Olympic Games.

It's important for Brazil to follow and continue analyzing the situation in order to define the proper spectrum utilization to meet the increased demand for mobile communications traffic during the 2014 World Cup.

6.5 NEW EMERGING THREATS

Among the new emerging threats that might affect users and mobile service providers in 2014, the most relevant have to do with the great crowds of people that are normal during World Cups, and also those related to new technology. This large number of mobile service users will require, besides normal contingency planning, that situations of mass denial-of-service and the use of illegal mobile towers be taken into account. This scenario becomes even more critical with the introduction of new services, with interactivity and integration between different components driven by powerful new technologies. New technology represents new vulnerabilities and new opportunities for users, service providers and hackers.

According to specialists, the 2010 World Cup will suffer from a huge number of cyber attacks from profit-seeking hackers. Various methods will be used to do this, such as siphoning off data from legitimate websites, phishing scams, and social engineering techniques. One example of this is the sale of counterfeit tickets for the 2010 Cup. One of the attack vectors is broadband services. By increasing attack risks and opportunities, they are very attractive to criminals. With convergence and mobility, cell phones and smartphones will be increasingly used as attack vectors[60].

The threats for the 2014 World Cup need to be defined by a methodology that will include the different strategic, operational and technological levels of critical telecommunications networks.

6.6 CRITICAL INFRASTRUCTURE PROTECTION AND SECURITY

The stadiums represent the last link in a very complex chain.

Outside the stadiums, we have information stands, parking lot management, smartcards, and access control. Inside the stadiums, we have electronic scoreboards, spotlights and video and television distribution systems. There are also ticket distribution systems and telecommunications, accommodations, lockers, broadcasting and power distribution infrastructures.

On another layer, we have the economic infrastructure of the country: traffic and airport systems, electric power generation, and the telecommunications backbone, among others. Prevention, detection and reaction will be essential. FIFA demands a redundant optical network to guarantee link stability. For the 2010 South Africa World Cup, this redundancy cost approximately US$ 150 million[61]. In a country with continental dimensions like Brazil, the challenge of meeting FIFA's redundancy requirement will be even greater.

During the 2006 World Cup in Germany, there were 32 teams, 12 stadiums, over 15,000media professionals, and over 20,000 FIFA staff members, organizing committee members and volunteers working at70 different locations.

Converged communications technology connected over 70 locations in Germany via the Internet and WAN (Wide Area Network) with a central database. All necessary communications services - phone calls, Internet access, e-mails, access control – were handled by this converged network[62].

IP telephony was used, with standardized numbering (4,500 extensions) and a central directory for fast access to contact information. Services provided included voice calls, e-mails, conference applications, voice mail, faxes and instant messaging.

The IT Command Center in Munich was set up to secure service availability during the event. There were identical installations at all the important locations, including the 12 stadiums, where the information was mirrored from the central server. Required network availability was 99.99%.

The personal data of accredited individuals and ticket holders, as well as FIFA's internal data traffic, had to be protected.

Matches could be followed on TV (including HDTV), on the Internet or on the cell phone via wireless network technologies.

To be able to work from their hotels, reception counters at airports and railway stations, FIFA and organizing committee staff had secure access to the network via a VPN (Virtual Private Network).

7 FINAL CONSIDERATIONS AND RECOMMENDATIONS

Major sporting events like the World Cup and the Olympics are tremendous opportunities to spark economic growth, since both the government and the private sector invest heavily in preparations for them, potentially leaving a legacy of development for the host country.

Trying to get the technology that will be available in 2014 to work over the current bands will greatly restrict the quality of service. Careful planning and implementation might mitigate this restriction, but there is no guarantee that this will be enough. Allocating a larger part of the spectrum for mobile services is an important factor to prevent this service from collapsing, not only during the 2014 World Cup, but for the population in general in the following years.

When it comes to telecommunications, we see a great opportunity to increase capacity and data speeds in Brazil's mobile networks. Guaranteeing the security and reliability of mobile networks for these large events is also crucial. The following recommendations are designed to benefit the entire mobile services value chain:

- **Planning jointly between the government and the private sector:** To ensure security and reliability of mobile networks in particular and telecommunications networks more broadly, mobile operators should work jointly with the association of cities representing the 12 host cities and the major event sponsors, agreeing on the possible locations for the eventual Fan Fests. Planning for the traffic and capacity of the networks must be aligned with the expectations of security and transportation agents.
- **Structuring partnerships with organizers of similar events:** The experience from other large sporting events is essential for the Brazilian players to acquire the needed

expertise to plan and execute these events to ensure their complete success. It is vital to seek partnerships with bodies such as the organizing committees of similar upcoming events, such as the South Africa 2010 World Cup and the London 2012 Olympic Games, or of previous events such as the German 2006 World Cup, the China 2008 Olympics and the Canadian 2010 Winter Games. Telecommunications service providers that covered these events or are planning future ones can provide valuable contributions to the 2014 World Cup in Brazil as well as the 2016 Rio de Janeiro Olympics. These partnerships can provide benchmarks and other parameters such as case studies and forecasts for planning and execution purposes.

- **Acquiring hands-on experience from upcoming similar events in Brazil:** Military World Games 2011 and FIFA Confederations Cup 2013, both in Brazil, are large sporting events that represent challenges to the telecommunications players. These hands-on experiences can contribute extensively to the planning and execution of the 2014 World Cup and 2016 Olympic Games.
- **Planning for innovative new services:** Mobile carriers, broadcasters and soccer team associations can use the next state and national championships – between 2011 and 2013 – to try out new services and applications based on broadband access and mobile TV. Real network traffic requirements can thus be forecasted and important aspects regarding usability, appeal, security and end-user quality of experience can be defined.
- **Planning capacity and traffic demand:** Detailed planning must be carried out beforehand regarding what services will be offered during the World Cup and their respective impact on traffic demand and processing capacity, considering the user profile, the estimated demand for roaming, and concentrated areas of high usage such as the stadium surroundings and Fan Fests. The Fan Fests that will take place during the 2010 World Cup South Africa will be an excellent opportunity for Brazil to evaluate the infrastructure needed to provide users with the best possible service. Event planning must also include suppliers' delivery and execution capacity. Another critical area will be media centers at the stadiums and cities, where traffic demand from Brazilian and foreign media professionals will be huge.
- **Allocating the frequency spectrum:** There is strong evidence that the frequency spectrum currently allocated in Brazil for mobile services will not be able to adequately cover the areas of great user concentration in the next few years. Anatel is taking actions in compliance with ITU recommendations to align Brazil's mobile service frequency spectrum with other countries around the world. An example is the 2.5 GHz band. For the 2014 World Cup and the 2016 Olympics, the importance of an adequate new band for mobile communications is underscored by the great concentrations of users with a high demand for mobile services. It is therefore highly recommended to continue seeking and evaluating different alternatives to increase the frequency spectrum for mobile services, such as the allocation of 140 MHz spectrum band for FDD in the 2.5 GHz in a timely fashion.
- **Adopting a model of critical infrastructure protection:** Using a critical infrastructure protection model will allow joint planning between the government, telecommunications service providers and the 2014 World Cup organizing committee to ensure that mobile services will work flawlessly during the event. This model must encompass at the very least the following activities: identification and analysis of the main assets; identification and analysis of the main threats and vulnerabilities in the environment, in the context of the 2014 World Cup and the 2016 Olympics; analysis

of the interdependency of the different sectors; risk analysis; and finally, the creation of an ideal scenario for critical infrastructure protection.

- **Defining contingency and business continuity strategies, based on delineated threats:** Once the critical infrastructure model has been defined, it is highly advisable to delineate contingency and business continuity strategies to improve the ability to react quickly and resolve problems. It is therefore crucial that, before risks are analyzed, this plan be defined, implemented and, most importantly, tested. Furthermore, all input from the organizing committee and information from FIFA itself, such as game databases, credentials and any other pertinent data must be taken into consideration.
- **Conducting in-depth analysis among all market players:** Each player should be developing an in-depth analysis to define the best solution for mobile users. This work must include at least the following tasks:
    - Identify what services will be offered to users and their required throughput.
    - Estimate the level of usage of these services and their relative weight on traffic demand calculations.
    - Identify priority areas with special coverage needs.
    - Assess network projects, infrastructure and frequency spectrum.
    - Identify internal or external threats, accidental or intentional, that can disrupt services.

This analysis might reveal that more frequency bands will be needed if the other factors involved (e.g., data compression or transmission technology) do not evolve sufficiently to meet increased traffic demand. A common strategy among all players is essential to secure the necessary measures from federal, state and local governments.

8 About CPqD

8.1 Identity

CPqD is an independent institution focused on innovation through Information and Communication Technologies (ICT), aiming at contributing to competitiveness and the digital inclusion of the society. It develops the most extensive research and development program in ICT in Latin America, fully dedicated to the development of ICT solutions for telecommunication, banking, finance, energy, and other industries, to both corporate and government sectors.

8.2 History

CPqD was established in 1976 by Telebrás, the holding company which controlled the public telecom services in Brazil, as a center for research and development in telecommunications. Since its inception, the company has been on the technological forefront, anticipating the needs of a fast paced and ever-changing society. In 1998, as a result of the privatization process of Telebrás, CPqD became a private-law corporation, broadening its scope of competencies to embrace new markets.

CPqD is located in the city of Campinas, state of São Paulo, in an area of approximately 3,873,600 square feet. Its offices and laboratories occupy an area of over 861,092 square feet.

8.3 Strategic Positioning

Employing over 1200 highly skilled professionals dedicated to achieving high levels of quality, CPqD is a globally integrated and dynamic organization, strategically positioned to add value to its customers through technological innovation and intelligence, widely recognized as a leading developer of ICT and important partner of the Government Administration. CPqD strengthens its position by providing a unique combination of skills and expertise.

The knowledge generated by CPqD reaches the market in the form of product technologies, software systems, technological services, consulting services, and intellectual capital supporting technology-based emerging companies. All this creates new job opportunities, increases the competitiveness of customers and partners, promotes digital inclusion in society and produces wealth for the country.

The product technologies developed by CPqD are transferred to several companies, which are then responsible for their production and commercialization.

The Operations and Business Support Systems (OSS/BSS) are CPqD's flagship software solutions, which have been successfully deployed in several organizations from different industries in Brazil and abroad. Considered as mission-critical systems, these solutions contribute to the reduction of losses, improvement of results, fraud prevention, improvement of customers' satisfaction and risk mitigation, resulting in higher efficiency and competitiveness for such organizations.

CPqD holds a wide range of telecom and IT solutions such as the information systems for Operation Support on Inside and Outside Plant Management, Workforce Management, Asset Management, as well as Business Support on Billing and Customer Care; Information Systems for Network Management, Speech Processing, Broadband Access Management, Digital TV, Business Intelligence, Wireline and Mobile Telecommunication Networks, among several other systems. CPqD's market share is integrated by customers from Government Agencies, the Electric Power sector, Financial Institutions and large Corporations. CPqD has provided outstanding contributions in the fields of Social Intelligence and E-Government, which direct positive effects in the welfare of citizens, minorities, small-scale companies, and the public administration.

CPqD laboratories offer more than 700 accredited tests and technological services in different fields. Some examples are optical fiber cables and accessories, switching and terminals, radio systems, electromagnetic compatibility, mechanic characterization, electrical safety, SAR, batteries and colorimetry.

The solutions developed by CPqD are present in Brazil and in several Latin American countries, in the USA, Angola, Samoa and Europe, where CPqD has established strategic business alliances with local companies.

8.4 CPQD CERTIFICATIONS

- ISO 9001:2000 Quality Management (http://www.iso.org)
- ISO 14001:1996 – Environmental Management (http://www.iso.org)
- CMMI Level 3 Software Engineering Institute (http://www.sei.cmu.edu)
- PMI Project Management Institute (http://www.pmi.org)
- Agência Nacional de Telecomunicações – Anatel (http://www.anatel.gov.br)

Anatel has designated CPqD as a Certifying Institute in the Brazilian Communication market, i.e., CPqD is allowed to evaluate and issue certifications within the Brazilian market.

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[4] 1 American Dollar (US$) = 1,91 Real (R$) – 1st March, 2010.

[5] Revista Exame, Issue 958, 12/16/2009.

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11 ITU, 2010. ICT Statistics Database for 2008. Accessed on 03/01/2010, available at: http://www.itu.int/ITU-D/ICTEYE/Indicators/Indicators.aspx# .

12 ITU, 2004. Trends in Telecommunication Reform 2004/2005 – Licensing in an Era of Convergence.

13 At that time the exchange rate was almost one-to-one, 1 American Dollar (US$) = 1,16 Real (R$)

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20 ANATEL, 2010. "Dados Relevantes do SMP por Plano, Região, Tecnologia e Estações Fixas Licenciadas". Data for February, 2010, available at: http://sistemas.anatel.gov.br/SMP/ Administracao /Consulta/TecnologiaERBs/tela.asp.

21 Anatel, 2008. "Estudo Técnico para Atualização da Regulamentação das Telecomunicações no Brasil". BRASÍLIA/DF: April 2008, pages 222 to 227.

22 Here we consider the sum of the 8.1 million 3G voice and data mobile handsets and two-thirds of the 4.9 million data-only terminals cited in Table 2. Today Anatel no longer presents information for data terminals segregated between the 3G ones and the less than 256 kbits data transfer ones but, based on historical data, it is reasonable to suppose that two-thirds of these data terminals are 3G and the remaining use other technologies such as General Packet Radio Service (GPRS).

23 Teletime VAS Guide.

24 Enter and Idate, 2009. Mobile 2009 – Facts & Trends. Accessed on 01/03/2010, available at: http://www.enter.ie.edu/cms/es/informe/5746/1 .

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27 The acronyms are derived from the name in Portuguese "Serviço Telefônico Fixo Comutado"

28 The acronyms are derived from the name in Portuguese "Serviço Móvel Pessoal"

29 The acronyms are derived from the name in Portuguese "Serviço de Comunicação Multimídia"

30 Official Federal Gazette, Brazil, February 14, 2008 (Diário Oficial da União, Ano CXLV, No. 30).

31 The acronyms shown are derived from the names in Portuguese.

32 S.L Ribeiro, E.T. Nakamura e E.K. Bezerra, Critical Infrastructure in Brazil. In: 1st IEEE International Workshop on Critical Infrastructure Protection, Darmstadt, Germany, 2005.

33 The acronyms shown are derived from the methodologies' names in Portuguese.

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[38] "Conectmídia Poll: Media Consumption Habits in the Convergence Era." Available at: <http://www.ibope.com/conectmidia/conexao/index.html>. Last access: 08/02/2010. 19,456 people aged 12 to 64 were polled.

[39] In-Stat, 2009. "Analog Mobile TV: The World's Most Widely Available Option for Mobile TV." Available at: <http://www.instat.com/promos/09/mobiletv.asp>. Last access: 09/02/2010. In Brazil, 287 analog mobile TV users were interviewed.

[40] Most digital mobile TV operators charge a monthly subscription fee of $3 to $20, depending on the region, with the exception of Japan (In-Stat, 2009).

[41] According to Decree 5371 of February 17, 2005: "Article 1. Retransmission Television (RTV) services are hereby defined as those dedicated to retransmitting the signals of the television broadcasting station (headend), simultaneously or non-simultaneously, to the general public free of charge.

[42] Under current regulatory laws, multi-programming is not a viable option for broadcast licensees. In thesis, the restriction of one service concession per locality, and the association of content with the frequency channel, because of the limitations of analog television systems, indicate that each broadcast licensee will only be able to offer one kind of program content per service area. According to Article 14 of Decree 52,795, of October 31, 1963: "3. The same entity, or people that are members of the board of directors and/or partners, cannot be granted more than one concession for the same kind of broadcasting service in the same locality. (Definition according to Decree No. 2108, of December 24, 1996.)"

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58 Name used to identify the service offered by cell phone operators in Brazil.

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