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Reform of the Regulatory Framework
Spectrum aspects

Costa Rica

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1. Executive Summary

The Reform of the Regulatory Framework is necessary given the opening of the telecommunication market. The new to be formed independent regulator SUTEL, under the umbrella of ARESEP is expected to be in charge of the Telecommunications Regulation and Spectrum Management & Monitoring.

Given the anticipated opening of the Mobile Services and the Internet Services clean spectrum is required to accommodate this :

Mobile spectrum available :

- 2 lots of 2 x 15 MHz of GSM 1800 spectrum (sub-band D and E)
- 4 lots of 2 x 15 MHz of IMT-2000 core band spectrum typically used for WCDMA, the leading global 3G technology

Also 1 or more small lots (a few MHz) of GSM 900 MHz spectrum could be made available after migration of some existing and/or allocated users for more cost effective rural roll-out.
850 MHz spectrum will only become available at a later point in time after TDMA has reached the final end of life. At that point in time the spectrum can be reallocated to 3G mobile services.

Internet/Broadband Access spectrum available :

- "Licensed" spectrum 2 x 100 MHz in the 3.5 GHz band for WIMAX and similar technologies. Potentially more in extension bands.
- "Unlicensed" spectrum, 84 MHz in the 2.4 GHz band and around 555 MHz in the 5 GHz band for WiFi, WIMAX and similar technologies.

It would be possible to open or clear more bands but initially this should not be necessary and is also not really recommended.

Mobile spectrum allocation/auctioning :
It is recommended to use the auctioning mechanism to allocate the mobile spectrum. Although many combinations would be possible one of the more obvious propositions, would be 2 new mobile entrants and each of them being offered 2 x 15 MHz of GSM 1800 and 2 x 15 MHz of IMT-2000 spectrum allowing for an integrated GSM/3G roll-out.
If possible a few MHz of 900 MHz spectrum should be allocated (and cleared) to all operators (ICE and 2 new entrants) to allow for more cost-effective rural deployment.
This would accelerate the mobile deployment both for low-cost rural services as well as for more advanced 3G (and ultimately lower cost) services in Costa Rica. New entrants are likely to roll-out an integrated GSM 1800/3G WCDMA network from the beginning since most Vendors offer such solutions already today.

Internet/Broadband Access spectrum allocation/auctioning :
It is recommended to start with allocating the **3.5 GHz** spectrum for licensed Internet services. Typically 4 channels should be allocated to an operator to allow for an initial efficient and large scale roll-out. At 3.5 MHz channels and FDD (Frequency Division Duplex) this would result in 2 x 14 MHz/operator and a maximum of 7 major national operators. Allocating 7 MHz channels would reduce this to 3 major national operators and 2 x 16 MHz for various smaller assignments.

Initial allocations of 2 x 14 MHz are recommended and an upgrade to 2 x 28 MHz should only be rewarded once there is proven large scale roll-out justifying the spectrum requirement.
Of course there is always the option to have regional licenses which share the same national spectrum allocation.

For the **3.5 GHz band,** as main "Licensed" spectrum being offered, either an auction or a beauty contest could be considered. In many countries this would be preceded by a public consultation. Since in Costa Rica allocating spectrum for Internet services is the actual consequence of the CAFTA agreement, it might be possible to target an auction and/or beauty contest immediately. However it is still recommended to perform some form of consultation to determine the interested bidders. These are not necessarily only large international operators but possible also many smaller local entrepreneurs interested in entering the telecom market.

For the "**unlicensed**" spectrum in the **2.4 GHz and 5 GHz** no specific process is necessary. This will allow many smaller initiatives to develop and deploy their own solutions.

National Frequency Plan

The National Frequency Plan should be updated to include the necessary adjustments for Mobile and Internet services.

Spectrum Management & Monitoring

A national spectrum management & monitoring system should be established to enable the Regulator to manage the spectrum. Besides the required monitoring equipment and training of staff also the enforcement capability should be addressed. Strict actions should be possible to stop illegal users of the spectrum and to assure payment of spectrum fees.

2 Introduction

This study for “Reform of the Regulatory framework, Spectrum aspects” is a continuation of various earlier studies done in 2005 like :

- Sector Overview and Key Input to Spectrum Policy
- Refarming the Mobile Spectrum, *Migration of Users*
- Spectrum Management & Monitoring, *Options and Issues Study*

These studies are still valid and a lot of additional background information can be found in these earlier reports. In this study the focus will be more towards the actual steps necessary to realise the Reform of Regulatory framework. Also new spectrum measurements have been performed to verify the continued validity of the earlier measurements and to detect any major changes in actual spectrum usage.

Spectrum : Why is it important?

The use of the radio spectrum has been growing over the recent years and a further increase in spectrum usage is anticipated as a result of the opening of the telecom market as indicated in the expected CAFTA agreement. In particular the growth of mobile telephony as well as increased spectrum usage for internet services will contribute to an increasing importance of spectrum usage.

Further growth as well as many new services based on 3rd generation mobile systems and (wireless) internet technology can be anticipated. All these services require 1 essential but limited resource : **Spectrum**

The radio spectrum is a limited national resource and efficient use of this spectrum is essential for the total Costa Rica economy since many businesses are directly or indirectly depending upon the use of interference free spectrum. Examples of businesses directly dependent upon sufficient, clean and well managed spectrum are :

- All Mobile operators. The current incumbent, ICE, as well as new entrants, this represents a rapidly growing business.
- The fixed operator is partly dependent upon spectrum to connect places to the national fixed telephone network as well as for Fixed Wireless Local Loop
- All radio and TV broadcasters
- All trunking operators providing radio communication services to companies
- All paging operators

Telecommunication is an important investment category and with the opening of the telecom market additional investments are anticipated.

Many more companies and organisations do depend indirectly upon the spectrum for their communication needs :

- Many government organisations use private radio networks (like police, utilities)
- Aeronautical, all communication with airplanes is using the spectrum. Clean spectrum is essential for safety reasons.
- Banks frequently depend upon radio links to connect their ATM’s
- Many businesses do depend upon mobile or radio communication to coordinate their activities. Even relatively new growth industries like tourism depend heavily on use of the spectrum (through mobile telephony) for their communications requirements.

All together the importance of spectrum use has exploded recently and failure to manage the spectrum efficiently would have detrimental impact on the overall Costa Rica economy.

3 Spectrum for Mobile Services

3.1 Existing Mobile Spectrum

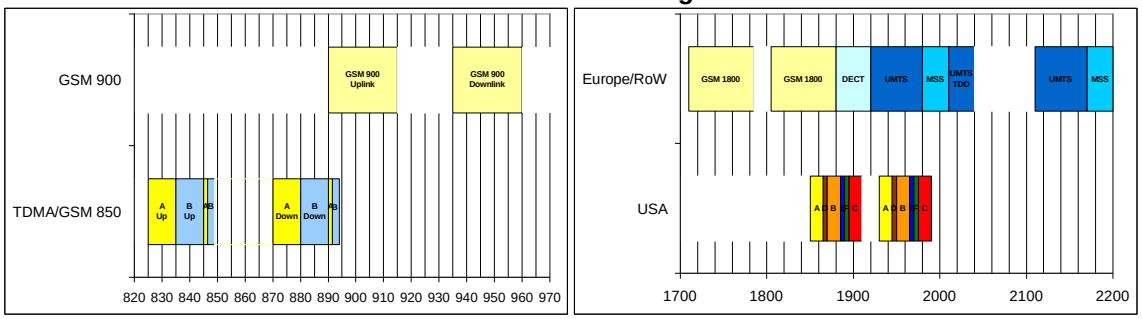
In Costa Rica two main mobile bands are in use :

- 850 MHz, Band A, B and extension bands (Rx 825-849 MHz, Tx 870-894 MHz). Both Band A and B are used by ICE for the TDMA network. International common practice is allocating Band A to an operator and Band B to a competitor.
- 1800 MHz band (Rx 1710-1785, Tx 1805-1880 MHz). ICE has deployed two separate GSM 1800 networks in this band. International common practice is allocation of this band to multiple operators. Up to 5 operators are not uncommon given the large amount of spectrum available.

Typically the lower band is used to provide coverage given the better radio propagation aspects while the higher band is used to provide high capacity given the larger spectrum.

The main mobile bands are :

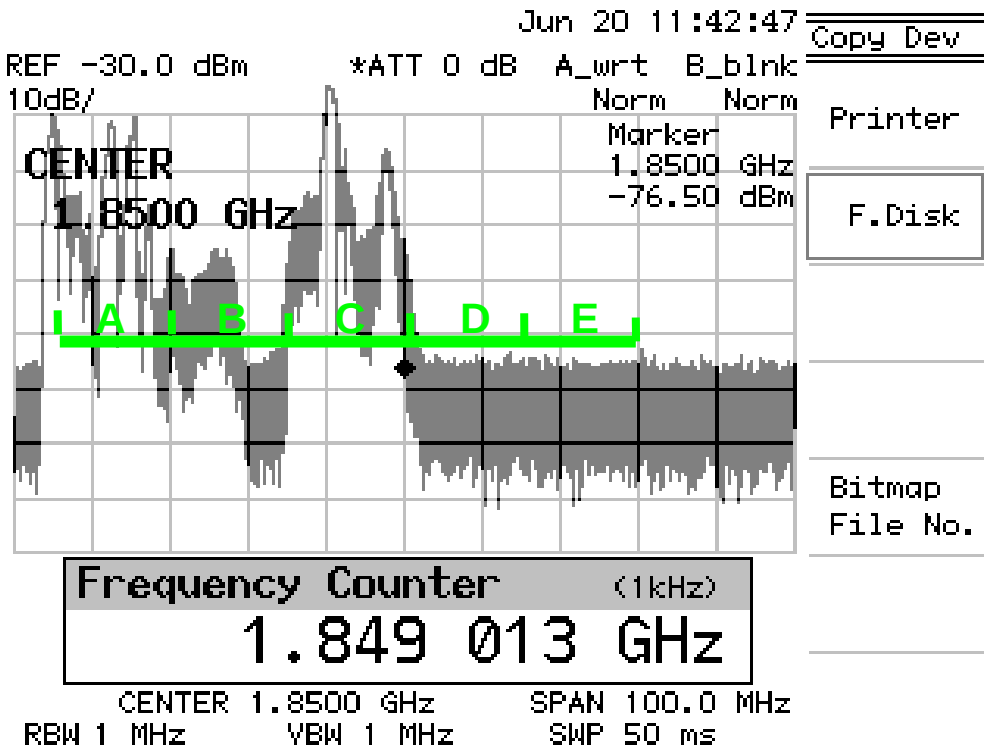
Lower bands 850/900 MHz **Higher bands 1800/1900/2100 MHz**



In May and August/September 2005 many sample measurements have been made both in and around San Jose, Volcano Irazu and various other high locations around the Central Valley area. Verification measurements made in June 2006 confirm a similar situation :

- Both 850 MHz Band A and B, including the extension band are in use (TDMA)
- The two GSM 1800 networks occupy most of the 1800 subband A, B and C while subbands D and E are still unused and available for new entrants.

The following verification measurement has been made with the DCNR Fixed Monitoring Station in San Jose on June 20th and from various high locations on Poas Volcano June 21st, 2006 :



Specifically, regarding the 1800 MHz mobile band, the following findings and recommendations can be presented :

- Sub-band A (Rx 1710-1725 MHz, Tx 1805-1820 MHz) was allocated by ICE to be used by the ALCATEL GSM network, when the first 400,000 GSM mobile lines were purchased (RFP #001-2001 of ICE).
- Sub-band B (Rx 1725-1740 MHz, Tx 1820-1835 MHz) has mostly been used to allocate additional spectrum to the ALCATEL GSM network.
- Sub-band C (Rx 1740-1755 MHz, Tx 1835-1850 MHz) was specified by ICE in the RFP for the next 600,000 GSM mobile lines, to be used by the awardee (ERICSSON) at the time when the contractor was chosen (RFP #7149-T of ICE).
- Thus sub-band D (Rx 1755-1770 MHz, Tx 1850-1865 MHz) and sub-band E (Rx 1770-1785 MHz, Tx 1865-1880 MHz) are the only ones that remain immediately available in the 1800 MHz mobile band.
- However ICE should be able to improve the spectrum efficiency of the Alcatel network and limit its usage to sub-band A. Even with the radio planning technologies which were considered base-line for GSM spectrum efficiency in 2002 this should be achievable.

Note: The 450 MHz band has various users and does not offer much capacity. Only small spectrum allocations could possibly be cleared from other users excluding this band for short-term large scale usage. However there could be some potential use in rural areas (like for example CDMA 450 MHz).

3.2 Future Mobile spectrum allocation

To allow for a second or third mobile operator to offer services in the Costa Rica the necessary spectrum should be reserved and kept free of other users. Therefore, it is highly recommended :

- To reserve the remaining parts of the 1800 band (Sub-bands D and E) to be awarded to future mobile networks.
- To reserve the IMT-2000 core band for future 3G Mobile Networks (Rx 1920-1980 MHz, Tx 2110-2170 MHz).

Further the following could be considered :

- The spectrum allocation to ICE in the 1800 MHz of two sub-bands (A+C or A+B) should be more than sufficient. The Alcatel network should be re-planned to fit in 1 sub-band. The preferred option is to use sub-bands A+B for ICE given their adjacency although technically the A+C option is also possible with only a small loss (1-2%) in spectrum efficiency due to some adjacent channel restrictions.
  As a result 1800 MHz sub-band C (or B) becomes available for future mobile networks.
- To gradually phase out the TDMA technology deployed in the 850 MHz band. The TDMA technology is gradually being phased out internationally. This will affect Costa Rica as well and at that stage at least one of the 850 MHz sub-bands can be relocated to another mobile operator.
  A gradual approach in line with the decline of the TDMA technology would be advisable to prevent migration costs. Once the subscriber base and/or the traffic start to decline reallocation of spectrum to 3G mobile services can be implemented.
- To allocate some GSM 900 MHz spectrum. This would allow for a more efficient roll-out of mobile services in the rural areas. Currently the 900 MHz band is utilised by many different users (like : ICE, COCESNA, Refinery, Bank of Costa Rica and many feeder links for Radio Broadcasting), but mostly concentrated in San Jose. With some effort this would allow use of some GSM 900 MHz spectrum in the rural areas. The allocation of 900 MHz spectrum is quite common in Latin America (except for a few countries) and the Caribbean as shown in the table below. Currently also Brazil is targeting the release of some GSM 900 spectrum.

Country	US Bands (MHz)	European Bands (MHz)
Anguilla	850 / 1900	900
Netherlands Antilles	850 / 1900	900 / 1800
Antigua and Barbuda	850 / 1900	900
Aruba	850 / 1900	900 / 1800
Barbados	850 / 1900	900 / 1800
Brazil	850	1800
Costa Rica	850	1800
Cuba	850	900
Dominica	850 / 1900	900 / 1800
El Salvador	850 / 1900	900
Grenada	850 / 1900	900 / 1800
Guyana	850	900
Cayman Islands	850 / 1900	900 / 1800
British Virgin Islands	850 / 1900	900
Jamaica	850 / 1900	900 / 1800
St. Kitts and Nevis	850 / 1900	900
St. Lucia	850 / 1900	900 / 1800
St. Vincent & the Grenadines	850 / 1900	900 / 1800
Suriname	850	900 / 1800
Trinidad and Tobago	850	1800
Uruguay	850 / 1900	1800
Venezuela	850	900

Source: Signals Telecom Consulting

Execution of these recommendations would leave ICE with around 2 x 12 MHz of 850 MHz spectrum and 2 x 30 MHz of 1800 MHz, together 2 x 42 MHz of spectrum for mobile services which is more than the typical international reference of 2 x 30 MHz of combined 850/1900 or 900/1800 spectrum for all 2 and 2.5 G networks.

There are several options to offer the spectrum to potential new entrants in the mobile services :

- Option 1 : 2 lots of 2 x 15 MHz of GSM 1800 spectrum
- Option 2 :4 lots of 2 x 15 MHz of IMT-2000 core band spectrum typically used for WCDMA, the leading global 3G technology
- Option 3 : 1 or more small lots (a few MHz) of GSM 900 MHz spectrum after migration of some existing and/or allocated users

Although many combinations would be possible one of the more obvious propositions, would be 2 new mobile entrants and each of them being offered 2 x 15 MHz of GSM 1800 and 2 x 15 MHz of IMT-2000 spectrum allowing for a GSM/3G roll-out.
If possible a few MHz of 900 MHz spectrum should be allocated to all operators (ICE and 2 new entrants) to allow for more cost-effective rural deployment.
This would accelerate the mobile deployment both for low-cost rural services as well as for more advanced 3G (and ultimately lower cost) services in Costa Rica. New entrants are likely to roll-out an integrated GSM 1800/3G WCDMA network from the beginning since most Vendors offer such solutions already today.

Given the expected timing of the spectrum allocation (early 2007) this represents a very attractive offer for new entrants, securing their upgrade to 3G without new auctioning processes, as well as for Costa Rica.

The alternative would be to split the auctioning in two steps :

- 2 new entrants with 2 x 15 MHz of GSM 1800 spectrum
- A 3G auctioning at a later stage allowing ICE, the 2 new entrants and other players to bid for 3G spectrum

This is likely to delay 3G developments in Costa Rica and reduces the value of the initial GSM 1800 auctioning given the uncertainty about the cost to add 3G later on.

It also should be anticipated that ICE would like to obtain 3G spectrum as well. Since there are 4 lots available and only 2 new entrants this should be no problem at all. Only the payment should be determined (same price as paid by the new entrants).

4 Spectrum for Internet Services

4.1 Spectrum Issues for Internet Services

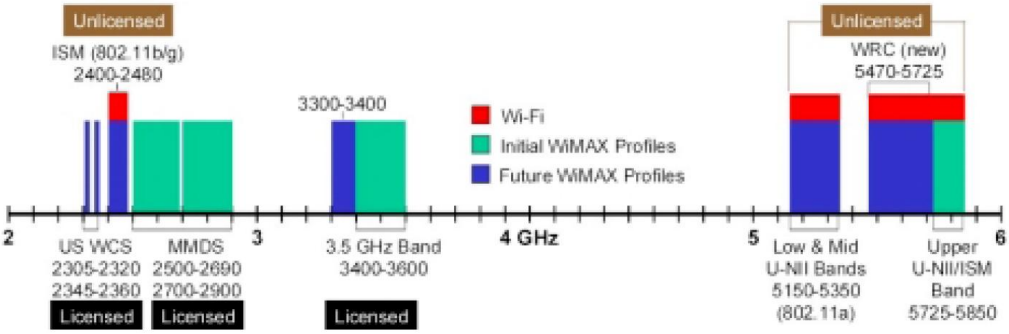
There are two major options to allocate spectrum to new Internet/IP based services :

- “Unlicensed” spectrum in the 2.4 and 5 GHz band
- Licensed spectrum in the 3.5 GHz or alternatively the 2.3 and 2.5 GHz bands

It is recommended to allocate both “licensed” and “unlicensed” spectrum.

The “unlicensed” availability of the 2.4 GHz band and the full 5 GHz band is essential for a rapid deployment of wireless internet services. This allows an accelerated deployment of internet services by local and grassroots initiatives in underserved areas.

It is highly recommended to make the “licensed” 3.5 GHz band (or alternative bands) available for multiple operators to enable them to rollout Broadband Wireless Access at a large scale.



Source : RF Spectrum use in WIMAX, Fujitsu USA

4.2 “Licensed” Spectrum for Internet Services

The key licensed band for Internet Services would be the 3.5 GHz band for several reasons :

- The 3.5 GHz band is widely used for this purpose in many Latin American countries, Mexico, Canada, Europe and the rest of the world (except the US)
- The initial WIMAX certification is focussing on the 3.5 GHz band (3.5 and 7 MHz channels FDD and TDD) enabling early use of standardised equipment instead of proprietary solutions.
- Given the global availability there is ample supply of equipment

The alternative licensed bands are the 2.3 (US WCS band) and the 2.5-2.7 GHz band as well as further extension bands (2.7-2.9 and 3.3-3.4 GHz). However the 2.3 GHz band is quite small and does not (yet?) has global support while the 2.5 GHz band is also intended for 3G services creating potential conflicting interest.
Further there is still some ICE microwave usage reported and measured in the 2.3 and 2.5 GHz bands although this seems to be at a limited scale. ICE has not yet provided an overview of its actual frequency usage in these bands.

Taking all this into consideration it is recommended to start with allocating 3.5 GHz spectrum for licensed Internet services. Typically 4 channels should be allocated to an operator to allow for an initial large and efficient scale roll-out.

At 3.5 MHz channels and FDD (Frequency Division Duplex) this would result in 2 x 14 MHz/operator and a maximum of 7 major national operators. Allocating 7 MHz channels would reduce this to 3 major national operators and 2 x 16 MHz for various smaller assignments. Initial allocations of 2 x 14 MHz are probably recommended and an upgrade to 2 x 28 MHz should only be rewarded once there is proven large scale roll-out justifying the spectrum requirement.
Of course there is always the option to have regional licenses which share the same national spectrum allocation.

4.3 “UnLicensed” Spectrum for Internet Services

The National Frequency plan, article 37, defines the 2.4 GHz band (2400 – 2483.5 MHz) as unlicensed spectrum for Spread Spectrum systems not exceeding particular maximum power output requirements. Also the 5.8 GHz band (5725-5825 MHz) has been defined as unlicensed spectrum for Spread Spectrum systems not exceeding particular maximum power output requirements in the 28 June 2004 adjustment of the National Frequency Plan.

The other typically “unlicensed” parts of the 5 GHz band (5150-5350 and 5470-5725 MHz) have not yet been released. It is recommended to release these bands as well to have more capacity available and to prevent too much pressure on the internationally favourite 5.8 GHz band.

The key unlicensed band for Internet Services would be the 2.4 GHz and the 5 GHz band for several reasons :

- Both bands are widely used all around the world
- WiFi is standardised for the 2.4 GHz and 5 GHz bands
- The initial WIMAX certification includes the 5.8 GHz band (10 MHz channels TDD) enabling early use of standardised equipment instead of proprietary solutions.
- Given the global availability there is ample supply of equipment

The regulatory requirement in this “unlicensed” spectrum should focus on the particular maximum output power and antenna requirements to allow many users to share these bands effectively. Recommendations very similar to the FCC Part 15 recommendations for both the 2.4 GHz and 5 GHz bands are often used by other Regulators in the region as well. These specific FCC Part 15 recommendations for the 2.4 and 5 GHz band are in general quite suitable this purpose and more appropriate for Costa Rica than for example the more restrictive regulations in Europe or Japan.

Besides applications using either 2.4 or 5 GHz band it should be anticipated that there will be mesh networks consisting of a mesh at 5 GHz (WiFi or WIMAX) and end-user access at 2.4 GHz (WiFi or in the future WIMAX).

5 National Spectrum Plan

Currently there is National Frequency Plan, dated 1998 and some smaller adjustments issued since then. It is available at www.controlderadio.go.cr. In particular the 28 June 2004 adjustment is relevant since this released the 5.8 GHz band.

However there are a number of aspects which do require an update :
Mobile :

- CR 2.44 : **850 MHz band** This clause should be updated to allow the future use of new generation mobile services once TDMA has been phased out
- CR 2.45 : As above but then for the TDMA extension bands
- CR 2.46 : The **900 MHz band** should be refarmed where needed to free up some spectrum for GSM 900 in rural areas. Existing allocations are often not (effectively) utilised.
- CR 2.47 : As above in CR 2.46
- CR 2.48 : As above in CR 2.46
- CR 2.49 : As above in CR 2.46
- CR 2.56 : 1700/**1800 MHz band**. Any use of microwave links in this band should be discontinued. In practice this has mostly been achieved by ICE but the National Frequency Plan should reflect this.
- CR 2.57 : **1800/1900 MHz band** : Mobile allocation is correct but it should reflect the use of the 1800 MHz subbands D and E for GSM 1800 type of systems and delete any reference to PCS frequency plan based systems.
- CR 2.58 : **IMT-2000 band (1900/2100)**. Should be updated and reference should be made to allocate 1920-1980, 2110-2170 MHz solely to 3G mobile systems.

Internet :

- CR 2.12 : **5 GHz band**. This clause should be extended to the 5150-5350 and the 5470-5725 MHz bands and not only 5725-5825 MHz and assure “unlicensed” use of this spectrum with technical requirements similar to the FCC Part 15 Recommendation.
- CR 2.61 : **2.4 GHz band**. This clause should be updated and assure “unlicensed” use of this spectrum with technical requirements similar to the FCC Part 15 Recommendation.
- CR 2.62 : **2.5-2.7 GHz band :** Use of fixed links in this band should be reduced and reallocation to future 3G expansion and/or Broadband Wireless Access should be accommodated in line with International developments
- CR 2.64 : **3.3-3.7 GHz band :** Allocation should be updated to include typical duplex operation of WIMAX FDD and TDD in this band

Further in the various microwave bands like the 6-8 GHz, 15 GHz, etc. it should become clear that not only ICE and some broadcaster can have links but any telecommunication operator can apply for spectrum for microwave links in the various designated bands.

Overall it might be recommended to gradually update other parts (like various global positioning systems, changes in satellite radio broadcasting, etc.) of the National Frequency Plan to bring it more in line with the current practice and expected future use. This could be an activity which can be synchronised with the WRC 2007 global coordination related to use of spectrum.

6 Spectrum Monitoring & Management

6.1 Existing Spectrum Monitoring

Currently, how is the Spectrum managed ?

The government has appointed DNCR as the regulator to take care of the spectrum. So almost all spectrum suitable for telecom services have been allocated to ICE. In a future, more competitive, market it becomes essential that the spectrum will be managed by the independent Regulator, currently SUTEL under the formal umbrella of ARESEP is assumed to become that regulator, and made available on a “fair” basis to different users given the limited availability of spectrum and the crucial roll of ‘clean’ spectrum for the users.

Currently DNCR issues licences for spectrum use through direct assignment. The main users are non-telecom : Radio/TV Broadcasting and Private Mobile Radio. To monitor the actual use of the spectrum DNCR has only limited tools and equipment.

Key issues

Given the anticipated dramatic growth in spectrum use in the coming years and the direct or indirect dependency of most businesses in Costa Rica upon spectrum usage, better spectrum monitoring and management has become necessary. The current key issues are :

- There is no central database for frequencies and information except for a very basic licence database. This results in inefficiencies, errors and insufficient enforcement. As a consequence legal spectrum users do suffer from interference in their frequency band. Also the government looses substantial revenues both from legal users not paying their annual fees as well as from illegal users not paying at all.
- Monitoring tools are basic and locating (illegal) users is difficult and slow. Therefore DNCR can not ensure that spectrum can be made available and kept free of interference and illegal use. Automatic location finding equipment is required.
- Spectrum allocation is very basic and there are very limited tools to plan more efficient spectrum usage.
- Non-payment of Spectrum Fees is an issue.
- Spectrum Fees are very low and are still based on the 1954 Law.
- Enforcement, there are no procedures resulting in ‘confiscation’ for illegal use and non payment of annual fees.

The DCNR has a fixed monitoring station in San Jose. This monitoring station is in actual operation with two monitoring positions. This is a rather basic system consisting of spectrum analysers and receivers but no automatic direction finding equipment.
The main equipment of this monitoring station is:

- Advantest R3131 Spectrum Analyzer 9 KHz – 3 GHz
- IFR 2398 Spectrum Analyzer 9 KHz – 2.7 GHz
- Rohde & Schwarz ESVP receiver 20-1300 MHz
- Rohde & Schwarz ESM 500 VHF/UHF receiver
- Panorama receiver
- Several commercial general purpose receivers/scanners and antenna systems

Further DCNR has a mobile unit for field measurements. The main mobile measurement equipment is an Anritsu Hand-portable Spectrum Analyzer

The current tools do not include any automatic monitoring or direction finding equipment. Locating an illegal transmitter easily takes a week or longer and requires extensive field work by skilled monitoring technicians with directional antennas. An automated spectrum monitoring system would, through triangulation, identify the expected location of an illegal transmitter within a few seconds. With a mobile monitoring station the exact location of the illegal user could be verified on the spot.

Currently there is no automatic monitoring station with direction finding capabilities in place. Only very limited tools and equipment are available. Locating illegal transmitters and collection of proof is very time consuming, inefficient and therefore ineffective.

Currently there is no Spectrum Management database available within DNCR. There is basically one subsystem containing parts of the data :

- DNCR has a database with the concessions/licenses sorted by frequency but this database does not contain any detailed technical information.
- Staff of the monitoring station seems to be using handwritten lists with the stations they can listen to properly. This is mainly associated with broadcasting users given the specific tasks DNCR has with respect to monitoring the Broadcasters.

However there is no spectrum management database to verify simple operational questions required in day-to-day spectrum management like :

- Location related information like which frequencies and users are present at this location?
- Frequency related information like where is this frequency already in use, by whom and with which transmit power and with which antenna systems?

All integration depends on the memory of individual staff members and is not secured in any central database.

Currently there is no Spectrum Management Database. Only partial information exists and is distribution over different departments and systems. Information required for spectrum management decisions depends only on the memory of individual staff members.

6.2 Proposed spectrum monitoring

Solution

DNCR requires **Spectrum Management & Monitoring** tools and **legal enforcement.** Various options for a Spectrum Management & Monitoring System have been reviewed. Key requirements are permanent monitoring in the San Jose/Central Valley area as well as the capability to monitor everywhere else in Costa Rica when needed. This has resulted in the following recommended monitoring network :

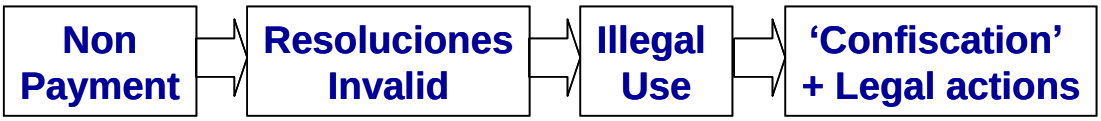
- 2 fixed/transportable permanent stations on the northern and southern mountains around San Jose and the Central Valley
- 1 fixed/transportable station with a permanent location in the north-western area
- 1 mobile station including antenna's
- 1 (Cerro Chirripo) or 2 (Caribbean and Pacific side) fixed/transportable stations with a permanent location in the southern areas.
- 5 or 6 antenna sets
    - 4-5 fixed sets VHF/UHF for the 4-5 fixed/transportable monitoring stations
    - 1 fixed set VHF/UHF for DNCR additional triangulation position

With this configuration most economically important areas can be monitored efficiently. . If extensive monitoring and locating of illegal users becomes necessary in more remote areas the mobile station could be deployed in that area temporarily without affecting the permanent monitoring elsewhere.

Besides the monitoring system a central database of all frequencies and their users should be created. This database will be the source of data for issuing new frequency assignment, monitoring actual usage, invoicing the users and collecting the fees. A

Frequency planning tool should be an integral part of the system to allow efficient allocation of frequencies.

On the enforcement side the procedures should be strengthened to allow 'confiscation' of equipment both in case of illegal use as well as in the case of consistent none payment of the fees.



With respect to the Spectrum Fees a review might be necessary. In particular for high value spectrum, like mobile bands, an appropriate fee or a substantial auctioning fee could be considered.

Benefits

An integrated spectrum management & monitoring system in combination with actual enforcement would bring the following benefits :

- Equips DNCR with adequate tools to manage and monitor the spectrum.
- Enables DNCR to collect the necessary legal proof against illegal users allowing more efficient enforcement
- Enables DNCR to collect a larger % of the fees.
- Reduced safety risks due to the capability to locate illegal users faster
- Cleaning up new bands required for future (mobile) expansion. This includes the GSM 1800 MHz, GSM 900 and the IMT core band (1900/2100) for both 2nd and 3rd generation mobile services. These bands do represent a high value when auctioned. Obviously investors paying a lot of money for these bands do expect them to be clean and free of illegal users. The government could expect substantial revenues from these bands directly (auctioning) and indirectly (investments, taxes, business generated by companies exploiting these new services).
- Cleaning up new bands for Internet Services. This will help to increase the Internet penetration in Costa Rica cost-effectively, also in the rural areas.
- Enables DNCR to handle international frequency coordination with neighbouring countries based on the capability to actually monitor usage in the border areas.
- Improved operational efficiency of DNCR.
- Improved DNCR credibility due to successful implementation and enforcement.

Estimated costs

The estimated costs of a cost-effective Spectrum Management & Monitoring system is 2.974 M $ (3.234 M $ if 2 monitoring stations, instead of 1, are required to cover southern Costa Rica) based on the requirements defined, actual 2005 quotes for equipment and estimates for expected implementation and customisation effort.

Conclusion & Action Plan

Currently situation

- DNCR Spectrum Management is fragmented
- Spectrum monitoring capability is insufficient
- Lack of enforcement

Proposed action plan

- Deploy an integrated Spectrum Monitoring & Management System
    - Further local investigation to prepare acquisition of the necessary locations
    - Obtain Government approval
    - Secure financing (World Bank)
    - Prepare & issue tender
    - Secure locations for monitoring stations
    - Select supplier
    - Implementation
    - Training
- Enhance enforcement procedures

Benefits :

- Improved operational efficiency of DNCR
    - Use of a common spectrum database
    - Automated monitoring and locating capabilities
- Increased revenues for DNCR & Government
    - Better revenue collection
    - More illegal users will become legal
    - Auctioning of bands
    - Indirect through taxes and economic development of all activities depending on spectrum for communication
- Major economic impact, without interference free spectrum there is no :
    - Mobile Telephony (some of them suffered high loss)
    - TV/Radio broadcasting
    - Telecommunication links to other cities
    - (Private) radio communication
    - Safety for government, aeronautical, etc.
- New mobile and internet services require spectrum. Only clean spectrum can be auctioned. Typical auctioning revenues are much higher than the cost of a Spectrum Management and Monitoring System.

6.3 Procedures for issuing licenses/concessions

After the New Telecom Law comes into force all “claims” for Spectrum should be settled within a few months. In particular ICE should disclose its **actual spectrum use**. For the mobile bands this has been verified by independent spectrum measurements but for other bands like for example microwave links a complete and comprehensive list should be submitted to prevent unnecessary reservations of unused spectrum.

DNCR should also compare the “official” license database with actual utilisation of the spectrum. Spectrum which is not actually used should return to the Regulator and can be issued to other parties.

The **actual spectrum usage** data of DNCR and ICE together forms the core of the actual spectrum usage database. From that moment on all new spectrum allocations should be made through the Regulator.

For most of the non-telecom users like PMR, Broadcasting, Aeronautical, Amateurs, etc. the spectrum, as far as it is not really scarce yet, can still be allocated on a first come, first serve basis.
Currently spectrum monitoring is not an integral part of the spectrum assignment process. However it is recommended to make spectrum monitoring an integral part of the spectrum assignment process.

For **(scarce) spectrum, like the mobile bands, auctioning** is an appropriate method to allocate the spectrum. Where needed a beauty contest element could be incorporated as a pre-selection mechanism to assure proper application of the spectrum afterwards.
An international preparation would be recommended to raise substantial international interest, establish clear process procedures, and to make sure that all potentially suitable candidates are aware of the opportunity to bid for Mobile Spectrum and the corresponding license.

For the **3.5 GHz band** as main option for “Licensed” spectrum either an auction or a beauty contest could be considered. In many countries this would be preceded by a public consultation. Since in Costa Rica allocating spectrum for Internet services is the actual consequence of the CAFTA agreement, it might be possible to target an auction and/or beauty contest immediately. However it is still recommended to perform some form of consultation to determine the interested bidders. These are not necessarily only large international operators but possible also many smaller local entrepreneurs interested in entering the telecom market.

For the “**unlicensed**” spectrum in the **2.4 GHz and 5 GHz** no specific process is necessary. This will allow many smaller initiatives to develop and deploy their own solutions.

It should be noted that a typical operator does require two licenses :

- A license to be a telecom operator
- A spectrum license for the use of frequencies

A non-Telco spectrum user typically requires only a spectrum license although for instance Radio & TV broadcasters might be subject to other licenses related to their broadcast activities as such.

6.4 Billing and Revenue collection of fees for Spectrum usage

Based on the data provided by DNCR the total revenues from Spectrum Fees are only around 50 M Colones. This amount is very low since the fees are still based on the 1954 Law and invoices charging 1$ for a microwave link have been observed. Besides the already low spectrum fees also the actual payment behaviour is reported to be troublesome. Many users neglect to pay their fees without facing any real consequences.

There is limited follow-up defined to actually collect revenues in case of non-payment. Overdue amounts are high and there is little enforcement and no system nor procedure for revenue assurance in place.
For a combination of reasons DNCR receives many payments late or not all leading to loss of revenue for the Government of Costa Rica.

It is essential to be sure about the correct invoice and to enforce payment. Currently the action resulting on none payment is an administrative fine. This seems to be not very effective since the fine isn't paid either. A more effective procedure could consist of :

- Prolonged non-payment => License/concession becomes void
- If any transmission takes place this should be classified as illegal since no valid license/concession exists
- Subsequent 'confiscation' of equipment and a parallel legal case would be appropriate.

Spectrum fees are very low and based on the old 1954 Law. The payment behavior is reported to be troublesome. Changes are required to improve the situation :

- Increase Spectrum Fees to reasonable level
- Proper system to send correct invoices and to track payments
- Legal enforcement.

6.5 Main usage of Spectrum

The main users of spectrum can be divided in two categories with different regulatory procedures :

- Broadcasting (TV, Radio)
- Telecommunication/radio communication use, currently mostly ICE

Seen from a frequency perspective the following table gives an overview of the main type users and the relevant monitoring aspect.

Frequency	Users	Comment
3 - 540 KHz	None	Very limited monitoring required
540 - 1750 KHz	AM broadcasters	Stable, no new licenses
1.75 - 30 MHz	5 users + radio amateurs	Stable, limited monitoring required
30 - 54 MHz	None	Very limited monitoring required
54 - 88 MHz	VHF TV broadcasting	Stable, few users only
88 - 108 MHz	FM Broadcasting	Full, many users including 69 local broadcasters Substantial monitoring required
108 - 135 MHz	Aeronautical Some VHF TV broadcasting	Monitoring required for safety reasons Stable, few users only
135 - 470 MHz	Many PMR users	**Extensive monitoring and enforcement required** **Illegal users, misuse of repeaters, etc.**
470 - 804 MHz	UHF TV broadcasting	Stable, few users only
804 - 960 MHz	Mobile bands, large operators	**This band represents major economic interests,** **Costa Rica's mobile communication and STL's** **Extensive monitoring and enforcement required**
960 - 1215 MHz	Aeronautical	Monitoring required for safety reasons
1215 - 1710 MHz	Point-to-Point and Point-to-Multipoint	Basic monitoring required
1710 - 2170 MHz	Mobile bands, large operators	**This band represents major economic interests, major mobile bands of Costa Rica** **Potential future auctioning, high value** **Extensive monitoring and enforcement required to maintain value**
2170 - 2400 MHz	Limited use, Internet, links, future mobile expansion	Basic monitoring required
2400 - 2483 MHz	Mainly free use, intensive	Short range, free use but potential problems between many users
2.5 - 3.4 GHz	Limited use, mobile expansion	Basic monitoring required
3.4 - 3.6 GHz	WIMAX, Broadband Wireless Access	Basic monitoring required,
4 - 40 GHz	Microwave links & satellite + 5 GHz Wimax/WiFi/BWA	Very directional, capability to verify required

The main bands requiring monitoring and locating of illegal users of the spectrum are in VHF/UHF up to 2170 MHz. In the lower bands like HF/MF/LF there are very few issues and problems.

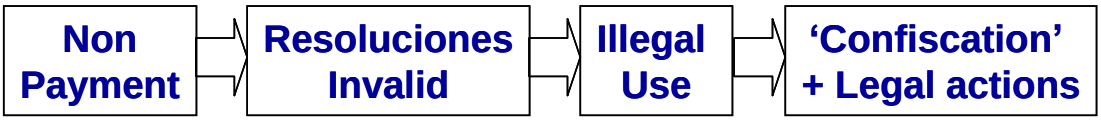
6.6 Enforcement of spectrum regulations

Currently enforcement of spectrum regulations is weak. First of all illegal users are difficult to localise given the limited tools and the lack of automated direction finding equipment. Once an illegal user has been localised it proves difficult to gather enough evidence to start a legal case.

What would be required is an automated spectrum monitoring system gathering the evidence quickly and efficiently followed by clear enforcement. Clear enforcement in this respect means immediate procedures resulting in 'confiscation' of the illegal transmitters followed by an appropriate legal case.

The legal users are entitled to swift action from DNCR instead of continued interference issues and loss of business as a result.

Another category requiring enforcement is the payment of the annual fees for legal users. The payment behaviour of spectrum fees is poor and non-payment is widespread. Some users haven't paid for years while they continue to use the spectrum. Also here enforcement is critical and a similar process like described in chapter 6.2 resulting in 'confiscation' of equipment might be required.



Enforcement of spectrum regulations is critical. Both in the case of illegal users as well as in the case of non payment of the annual fees strong enforcement is required to achieve the desired results.

6.7 Regulatory steps to be taken

A number of regulatory steps should be taken before or shortly after the approval of the new telecommunications law :

- Preparation of the **auctioning process** of the combined spectrum **1800/3G and mobile operator license**. Although in principle an operator license is not linked directly to a frequency license, in this particular initial licensing case it should be treated as one integrated offering of both the telecom operating license and the frequency license.
- Preparation of the auctioning and/or beauty contest process for the **3.5 GHz band lots for Internet services**. Also in this case an integrated offering (spectrum + operator license) would be required.
- Preparation of the (Internet) **operator license/registration procedure** for operators using **"unlicensed" spectrum**.
- An **update of the frequency licensing process** in general. All frequency licenses should be issued for a clearly limited time period and with a clear clause cancelling the license if not used within a reasonable period of time.
- The **spectrum fees**, based on very old legislation, should be raised to reasonable level. Both to cover the cost of the regulatory effort and spectrum management & monitoring and to prevent that spectrum is so extremely cheap to "hold".
- Besides the currently very simple **allocation of frequencies for microwave links** (mostly for radio and TV broadcasting) it will be necessary to start a more sophisticated frequency licensing procedure to allocate microwave frequencies. The expected increase of demand for microwave links will create the necessity to realise better spectrum reuse of microwave frequencies. In particular in the popular 6-8 GHz band used for long-haul links this will be evident while in the higher bands there is more spectrum and easier frequency reuse.
  The necessary procedures should be put in place to allow for proper reuse within Costa Rica. Initially this can be avoided by giving the operators each some dedicated subbands in the various microwave bands and making the frequency reuse an operator internal issue (like ICE today). However in the long-run the Regulator should be able to share the same frequencies between different users for these higher frequency bands.
- **Internal procedures** must be developed around the expected new **spectrum management & monitoring system** to utilise the capabilities and to improve the day-to-day operation.
- **Update of the National Frequency Plan.** This activity can be synchronised with WRC-07, the main global spectrum coordination in 2007.

Further all existing users should formally declare their detailed actual usage of spectrum to allow for a clear start. In particular a clear overview from ICE's actual usage is important since the currently "claim" allocation of almost all telecom related spectrum but in many cases only need and/or use only a small fraction of the total allocation. The remainder should return to the available pool of spectrum to be allocated by the regulator. Where necessary, validation measurements should be performed to verify the actual spectrum usage.

7 Conclusions

This report has outlined the options to allocate spectrum for new entrants in the market offering Mobile and Internet services. The spectrum to be allocated to these new entrants has been identified.

For Mobile services the GSM 1800 subband D and E as well as the IMT-2000 3G spectrum is mostly unused and readily available. The allocation of some lower band frequency spectrum requires a (feasible) migration/clean up of the GSM 900 MHz band to allow for a more cost-effective rural roll-out.

For Internet services the “licensed” 3.5 GHz and the “unlicensed” 2.4 and 5 GHz bands could be utilised.

The National Frequency Plan of 1998 should be updated accordingly.

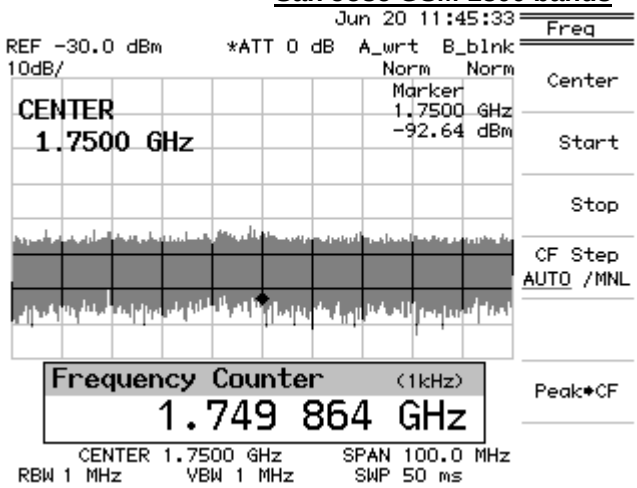
Auctioning is recommended as main allocation tool for scarce spectrum like the mobile bands.

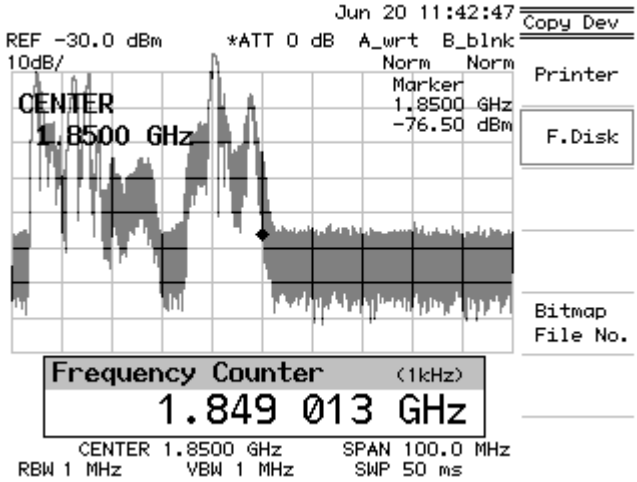
The Spectrum Management & Monitoring function should be established within the new regulatory body SUTEL and incorporate the previous DNCR activities. A national Spectrum Management & Monitoring system is required to provide the necessary tools.

Annex 1 Latest spectrum measurements

A number of new spectrum measurements have been performed since the previous measurements are already from May and September 2005. Both at the central DNCR monitoring station in San Jose as well as from 3 different high elevation locations on Poas Volcano with a view over the Central Valley verification measurements have been performed.

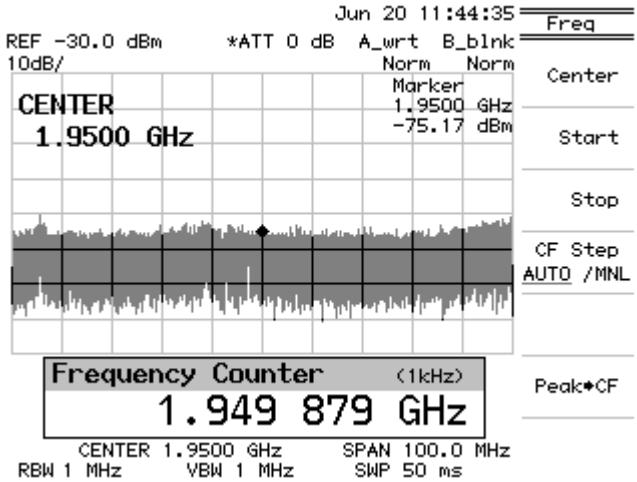
San Jose GSM 1800 bands

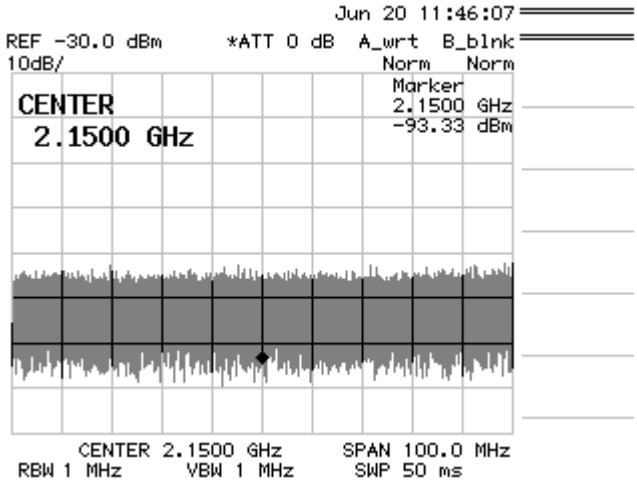




Typical usage of ICE GSM 1800 in subbands A, B and C. Unused subbands D and E

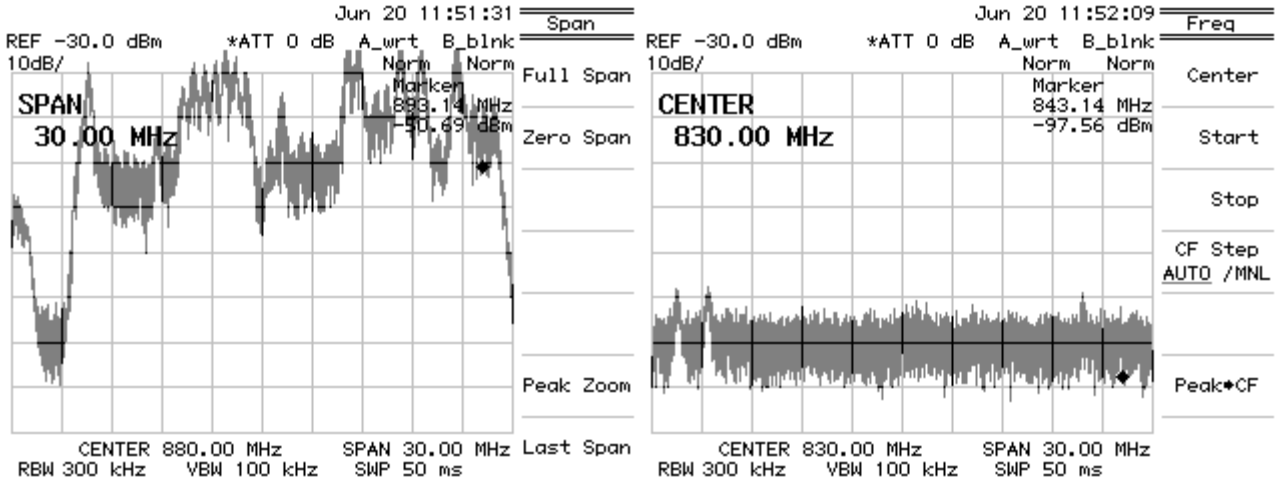
San Jose IMT-2000 bands





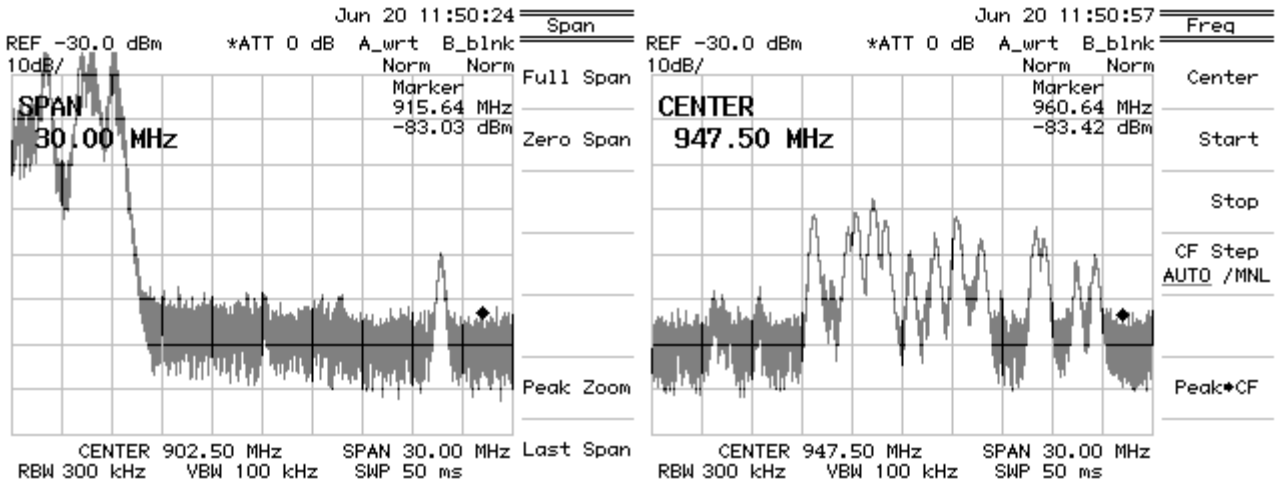
No major usage and an unidentified microwave link just outside the 3G band

San Jose 850 MHz band



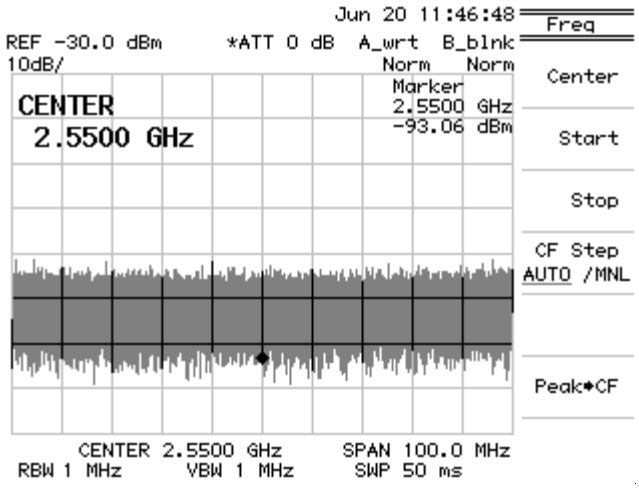
Typical usage of ICE TDMA networks and some other (trunking) systems next to it

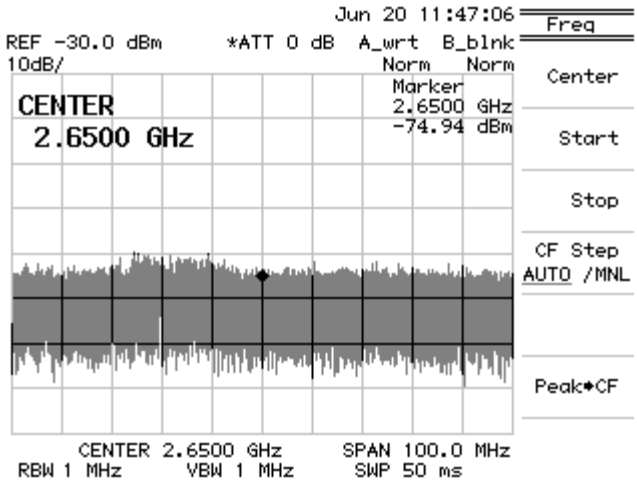
San Jose 900 MHz band



GSM 900 MHz uplink band is mostly idle above the 894 MHz (upper limit of ICE TDMA) while the downlink band shows many STL links but also some unused slots.

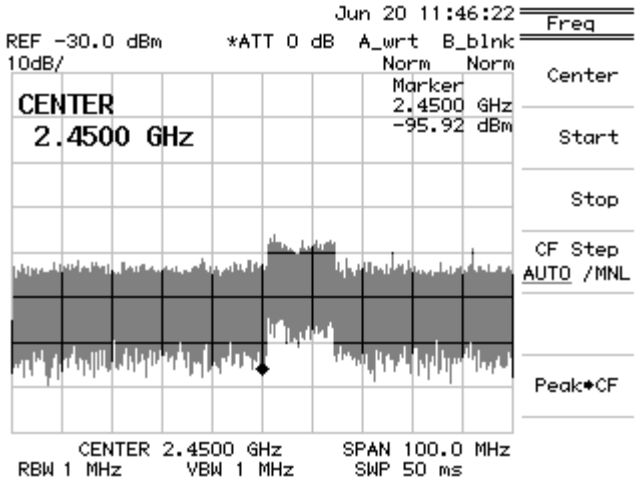
San Jose 2500 MHz band





The 2500-2700 MHz band shows very little usage except for probably some very weak and unidentified microwave links.

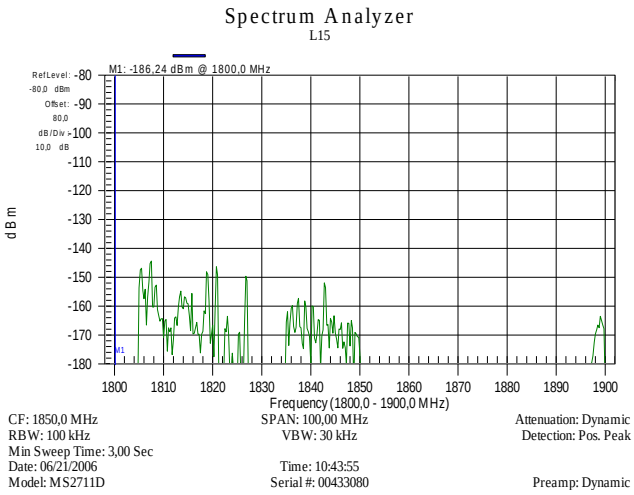
San Jose 2400 MHz band

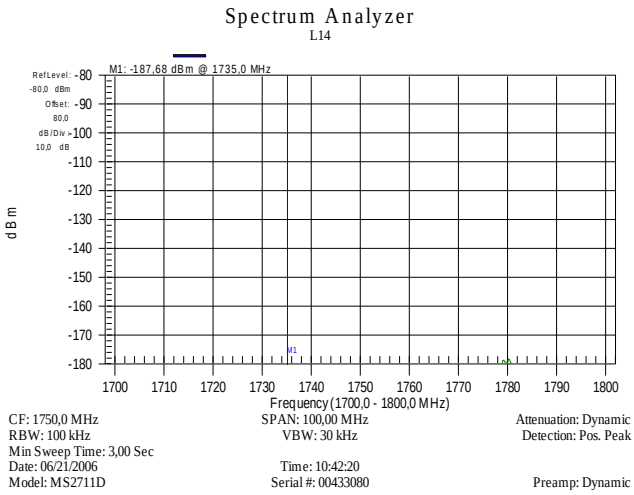


This band shows some obvious WiFi usage. All over the city there are low power users in this band.

Unfortunately the higher bands like the 3.5 GHz and the 5 GHz band could not be measured since there was no measurement equipment capable to monitor these bands.

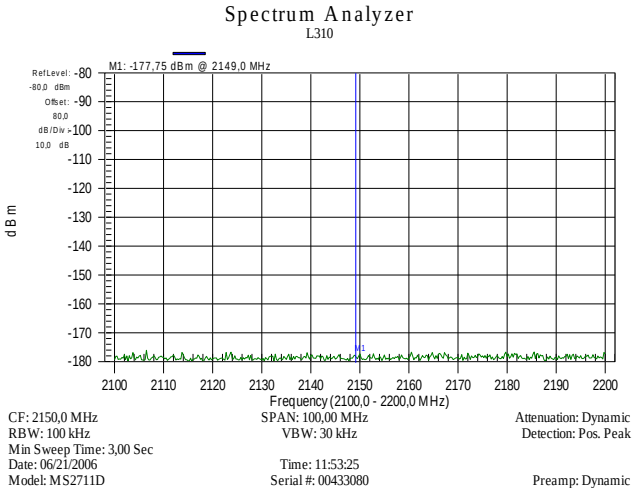
Poas Volcano 1800 MHz band

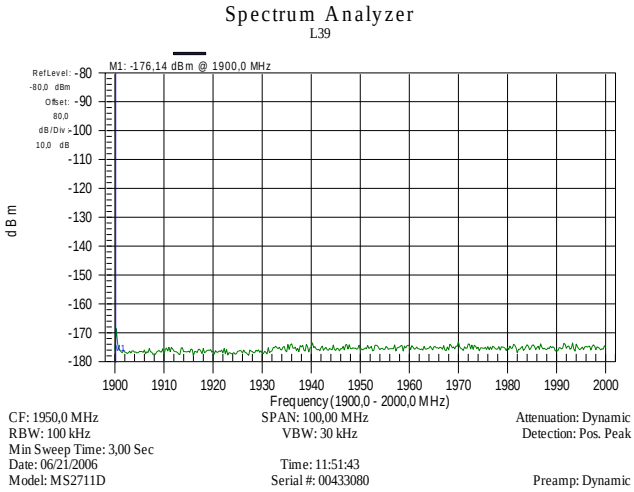




Typical usage of ICE GSM 1800 in subbands A, B and C. Unused subbands D and E. An unidentified signal, most likely a microwave link, just outside the GSM 1800 band.

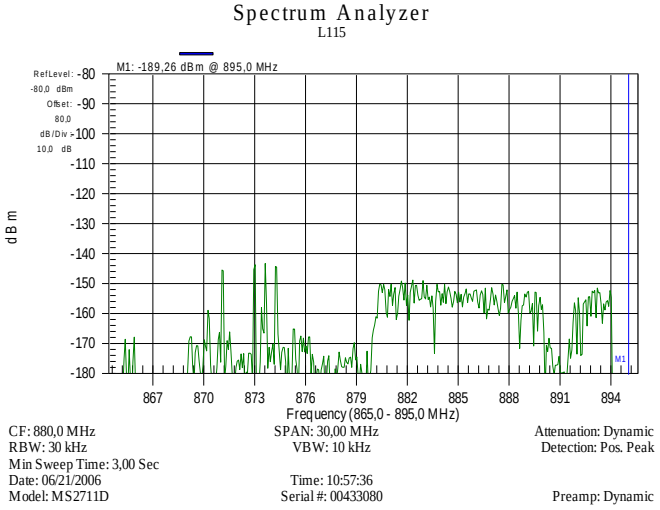
IMT-2000 band





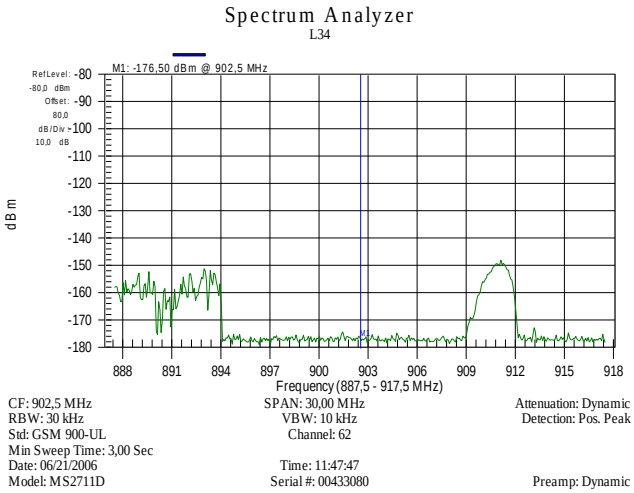
No major usage and an unidentified microwave link just outside the 3G band. Only in the direction of San Ramon some low level signal could be detected. Possibly there are still some remaining microwave links in that area.

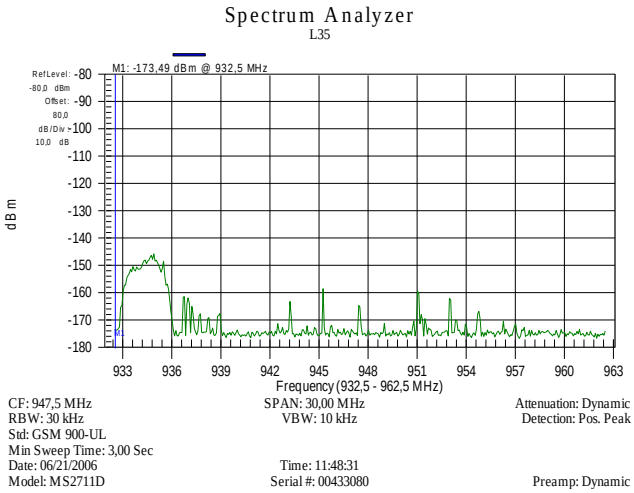
Poas Volcano 850 MHz band



Typical ICE TDMA usage and some other systems lower in the band.

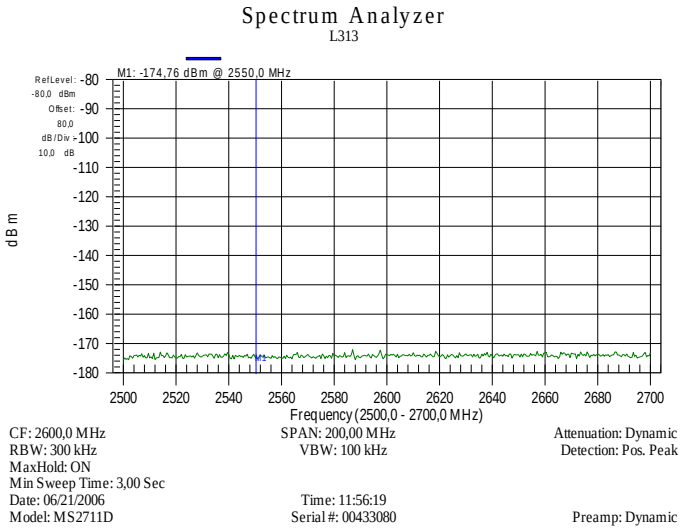
Poas Volcano 900 MHz band





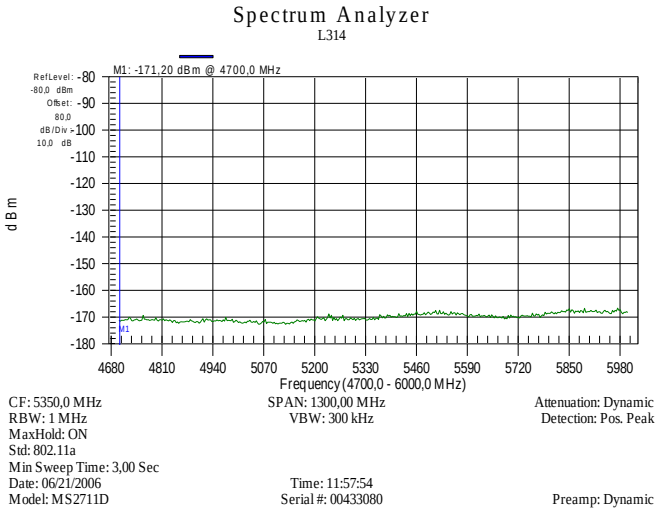
The GSM 900 MHz band shows the ICE TDMA up till 894 MHz and two Cocesna Microwave links (911 and 935 MHz) from the nearby Cocesna tower. Further there is usage in the 900 MHz downlink band but also quite some unused slots in-between.

Poas Volcano 2500-2700 MHz band



No real usage detected

Poas Volcano 5 GHz band



No real usage detected.

Unfortunately the 3.5 GHz band could not be measured since there was no measurement equipment capable to monitor this band.