Radio Spectrum Resource Assessment of the band 450 MHz to 5 GHz

SRMC & GSMA

2014.07

450MHz-5GHz 关注频段频谱资源评估报告

国家无线电监测中心

全球移动通信系统协会

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0. Executive Summary

At the World Radiocommunication Conference in November 2015 (WRC-15), Agenda Item 1.1 will consider additional spectrum allocations to the mobile service on a primary basis and identification of additional frequency bands for IMT and related regulatory provisions, to facilitate the development of terrestrial mobile broadband applications. Based on the input contributions submitted to ITU-R WP 5D, spectrum requirement prediction of IMT in China will be a total of 570-690 MHz by 2015, and 1490-1810 MHz by 2020.

Given the scarcity of radio spectrum resource, finding this amount of available, technically suitable and internationally harmonized spectrum to meet the predicted shortfall is a difficult task for any administration. Based on the monitoring experience of SRMC, and using the best international practice, this report assesses the current spectrum occupancy in China of selected frequency bands in the range of 450 MHz to 5 GHz.

The report found that bands measured have varied occupancy ratio, and while some incumbent services seem to use their allocated spectrum more than other services, there is still scope for a more efficient usage in most of the bands. Therefore, this report also looks at 5 options to increase spectrum utilization: Band segmentation, Band clearance, Geographical sharing, usage of Exclusion zones and Dynamic Spectrum Access. The suitability of each option for the bands is summarized in the table below.

Band	Band Segmentation	Band Clearance	Geographical Sharing	Exclusion zones	Dynamic Spectrum Access
470-694 MHz	√*				√
694-790 MHz	√	√			√
1300-1527 MHz	√*			√*	
2700-2900 MHz	√*	√*	√	√**	√
3300-3400 MHz	√		√	√	√
3400-3600 MHz		√*	√		
3600-4200 MHz	√*		√*		
4400-4500 MHz	√	√			
4800-4990 MHz	√	√			

*: Represent GSMA views, based on the monitoring results from section 4.
**: Only proposed to be applied in local area

However, the feasibility of these options will also depend on factors not addressed in this report, such as the costs of implementing any of these options, and administrations should carry out further studies, before they adopt the most proper appropriate measure. It is hoped this report would provide valuable information for decision makers in the national preparation process for WRC-15.

0. 摘要

在 2015 年 11 月召开的世界无线电通信大会上，1.1 议题将审议为作为主要业务的移动业务做出附加频谱划分、确定 IMT 附加频段以及相关规则，其目的是促进地面移动宽带应用的迅速发展。根据 ITU-R WP5D 提供的数据，预计中国 IMT 频谱需求到 2015 年将达到 570-690MHz ,到 2020 年将达到 1490-1810MHz。

考虑到无线频谱资源的稀缺性，对于任何一个主管部门，为了满足预计的频谱需求，寻找到数量足够、技术可行、国际协调的频谱资源，都是一项非常困难的任务。基于 SRMC（国家无线电监测中心）在无线电监测方面的充足经验以及国际上开展的有益实践，本报告将对中国 450MHz-5GHz 频段关注频段的频谱占用情况进行评估。

对各频段的占用度测量结果表明，不同频段的频谱占用度差别很大，部分现有业务相对其它业务会更多地使用频谱，大部分频段的使用效率还有提升空间。因此，本报告提供了 5 种可能的提高频谱利用的方法：频段转移和压缩、清频、频谱共享、使用隔离区、动态频谱接入。综合 SRMC 和 GSMA（全球移动通信系统协会）的意见，各频段适用的优化方法如下表所示。

频段	频段转移和压缩	清频	频谱共享	使用隔离区	动态频谱接入
470-694 MHz	√*				√
694-790 MHz	√	√			√
1300-1527 MHz	√*			√*	
2700-2900 MHz	√*	√*	√	√**	√
3300-3400 MHz	√		√	√	√
3400-3600 MHz		√*	√		
3600-4200 MHz	√*		√*		
4400-4500 MHz	√	√			
4800-4990 MHz	√	√			

*: GSMA 方面的建议

**: 仅用于局部区域

但是，这些优化方法的可行性还取决一些本报告没有涉及的因素，如实施这些优化方法所需的成本等。主管部门应当在采取最为合适的优化方法之前，开展进一步的研究。希望本报告能够为决策者在 WRC-15 的准备过程中提供有价值的信息。

1. Introduction

Spectrum is limited natural resources and its economic and social value has been recognized worldwide. Spectrum demand is growing fast in recent years. Some factors have a great influence on the spectrum allocation and spectrum efficiency, such as frequency bands which are allocated to different radio services, spectrum management methods on different radio applications, transceiver technology used in different radio communication systems. Additional economic value of the spectrum can be achieved by optimizing these factors, especially by introducing new or improved technology.

This report is drafted according to the cooperation agreement between the State Radio Monitoring Center (SRMC) of China and the GSM Association (GSMA). In this report, the related ITU (International Telecommunication Union) Recommendations and Reports are referred, and the occupancy of the frequency bands proposed by GSMA are measured and analyzed based on the monitoring experience, and best international practice.

According to [1] and [2], the characteristics of major radio applications which are allocated to these bands and related information on radio stations are summarized. Measurement methods are formulated and the test results are analyzed. Concerned measurement parameters include test location, time, equipment and parameter setting. Average frequency band occupancy in the bands is calculated based on the measurements in different regions. Finally, the spectrum resource usage is evaluated and advices to optimize the spectrum resource utilization are provided.

2. Frequency allocation and station information

2.1. Frequency bands

The frequency bands picked for this study are 470-790 MHz, 1300-1527 MHz, 2700-2900 MHz, 3300-3400 MHz, 3400-3700 MHz, 3700-4200 MHz, 4400-4500 MHz, and 4800-4990MHz. These bands have been proposed as suitable frequency ranges by WP5D and all remained as candidate band in the draft CPM text after technical studies by the ITU-R Joint Task Group 4-5-6-7.

The spectrum occupancy of the above frequency bands was measured except for 566-606 MHz, which is not convenient to announce measurement result according to related civil provisions. Results were adjusted according to the equipment configuration and testing ability in different regions.

2.2. Frequency allocation in each band

According to document [1] and [2], the frequency allocation of concerned frequency bands in mainland China is shown in Table 1.

Table 1 Frequency allocation in each band in mainland China

Bands（MHz）		Primary Services	Secondary Services
470-790	470-485	Broadcasting, Space operation, Space research	Fixed, Mobile, Radiolocation
	485-566	Broadcasting	Fixed, Mobile, Radiolocation
	566-606	Fixed, Mobile, Radionavigation, Radiolocation	
	606-610	Broadcasting, Radionavigation, Radio astronomy	Fixed, Mobile
	610-614	Broadcasting, Radio astronomy	Fixed, Mobile
	614-790	Broadcasting	Fixed, Mobile
1300-1527	1300-1350	Aeronautical radionavigation, Radiolocation, Radiodetermination-satellite (earth to space)	
	1350-1400	Radiolocation	
	1400-1427	Earth exploration-satellite (passive), Radio astronomy, Space research (passive)	
	1427-1429	Space operation (earth to space) , Fixed, Mobile (except aeronautical mobile)	Radiolocation
	1429-1452	Fixed, Mobile	Radiolocation
	1452-1467	Fixed, Mobile, Broadcasting, Broadcasting-satellite	Radiolocation
	1467-1492	Fixed, Mobile, Broadcasting-satellite	Broadcasting, Radiolocation
	1492-1518	Fixed, Mobile	Radiolocation
	1518-1525	Fixed, Mobile	Space operation (earth to space), Radiolocation
	1525-1527	Space operation (earth to space), Fixed, Mobile-satellite (space to earth)	Exploration-satellite, Mobile, Radiolocation
2700-2900		Aeronautical radionavigation, Radiolocation	
3300-3400		Radiolocation, Fixed, Mobile	Amateur
3400-3700	3400-3500	Fixed, Fixed-satellite (space to earth)	Amateur, Mobile
	3500-3700	Fixed, Fixed-satellite (space to earth) , Mobile (except aeronautical mobile)	

3700-4200	Fixed, Fixed-satellite (space to earth)	Mobile (except aeronautical mobile)
4400-4500	Fixed, Mobile	
4800-4990	Fixed, Mobile	Radio astronomy

2.3. Registered radio station information

The typical radio systems in each band and the number of radio stations registered are shown in Table 2, which are from the registered station database.

Table 2 Registered station information of the main services

Bands（MHz）	Typical Services	Typical Operating Systems	Amount of stations
470-790	Broadcasting	Analog/Digital TV	Thousands
	Fixed	Microwave relay communication system	Hundreds
	Aeronautical radionavigation	Radar	Dozens
1300-1527	Radiolocation	Meteorological Radar	Dozens
	Radio astronomy	Hydrogen spectral lines observing system	Dozens
	Fixed	Microwave relay communication system	Thousands
	Broadcasting-satellite	BSS	Planed
	Aeronautical mobile	UAS (civilian)	Planed
	Mobile	Private digital trunking network	Hundreds
2700-2900	Radiolocation	Primary radar	Hundreds
	Aeronautical radionavigation	Meteorological	Hundreds
3300-3400	Radiolocation	Radar	Dozens
3400-3700	Fixed	Wireless access (center station)	Hundreds
	Fixed-satellite	Earth station	Thousands
3700-4200	Fixed	Microwave relay communication system	Hundreds
	Fixed-satellite	Earth station	Thousands
4400-4500	Fixed	Microwave relay communication system	Hundreds
4800-4990	Fixed	Microwave relay communication system	Hundreds

3. Frequency occupancy measurement methodology

This section describes the occupancy measurement methodology used in this study. This is following principles outlined in [3] and [4].

3.1. Test sites

In order to reflect the real use of the spectrum in the bands, the test sites should be selected following the principles:

1) In the metropolis where the radio applications are more extensive.
2) The regions under test should cover the main radio propagation environment.
3) Requirement on the test condition should be met.
4) Based on reported use from licensing data.

Based on the principles above, the test sites were decided in Beijing, Shenzhen and Chengdu as shown in Figure 1, to cover all the scenarios including dense urban, urban, suburban, rural, and mountain.

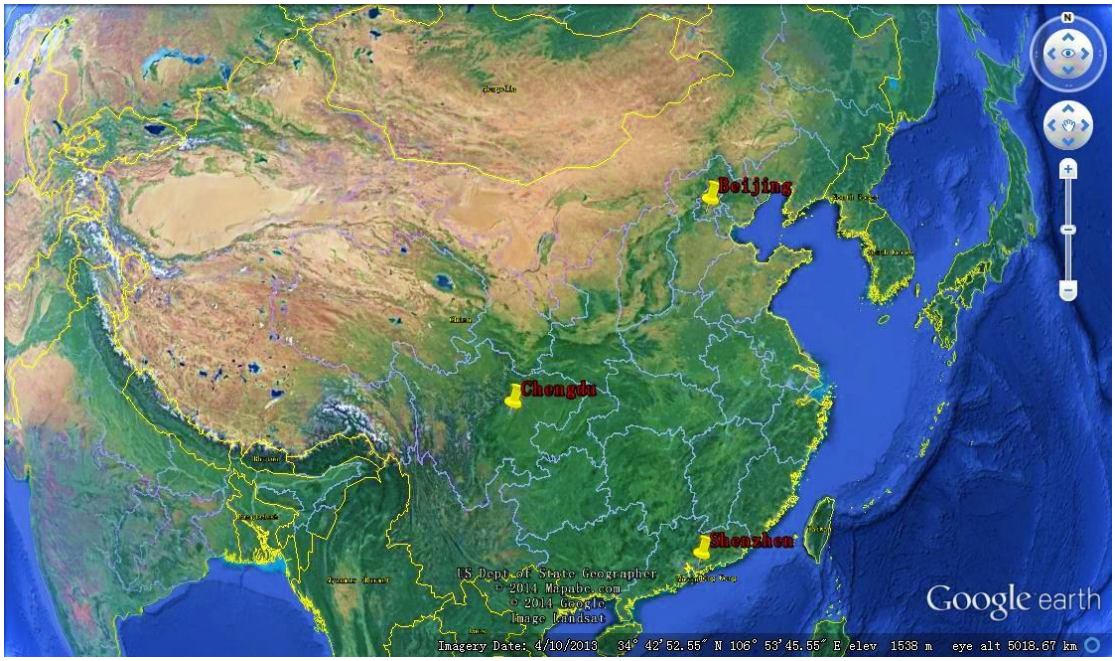


Figure 1 Test cities

The related information on test sites in the above cities is given in Table 3 and Table 4 with test scenarios and antenna heights to the ground.

Table 3 Information of test sites (below 3GHz)

City	Sites	Scenarios	Antenna Height to the ground	Antenna Height to the sea level
Beijing	Aoti	Dense urban	80 m	125 m
	Jichang	Suburban	40 m	70 m
	Mangshan	Mountain	20 m	640 m
	Tongzhou	Rural	80 m	100 m
	Yizhuang	Urban	60 m	90 m
	Yuanmingyuan	Suburban	30 m	75 m
Shenzhen	Futian	Urban	60 m	90 m
	Longgang	Suburban	15 m	30 m
Chengdu	Yanshikou	Urban	85 m	585 m
	Wenjiang	Suburban	10 m	530 m

Table 4 Information of test sites (3-5GHz)

City	Sites	Scenario	Antenna Height to the ground	Antenna Height to the sea level
Beijing	Fuchengdasha	Dense urban	10 m	50 m
	Yidongshejiyuan	Suburban	30 m	80 m
Shenzhen	Futian	Urban	60 m	90 m
	Longgang	Suburban	15 m	30 m

According to the monitoring ability and the device configuration, test scenarios are different in each city, which are shown in Figure 2, Figure 3 and Figure 4.

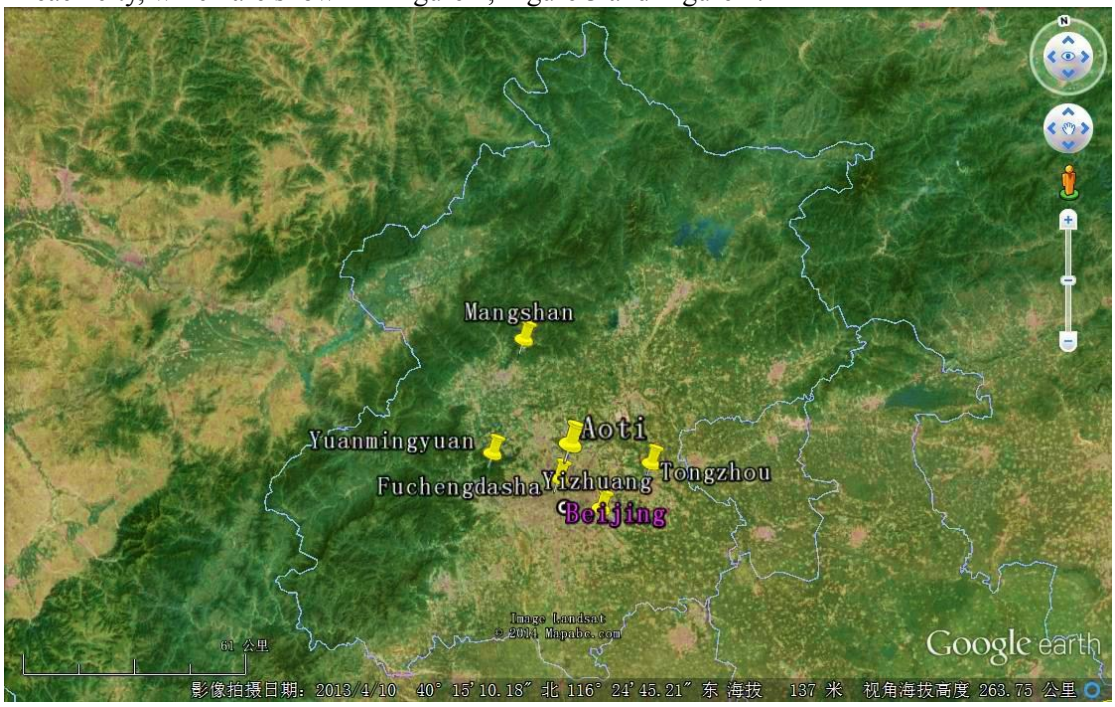


Figure 2 Test sites in Beijing



Figure 3 Test sites in Shenzhen

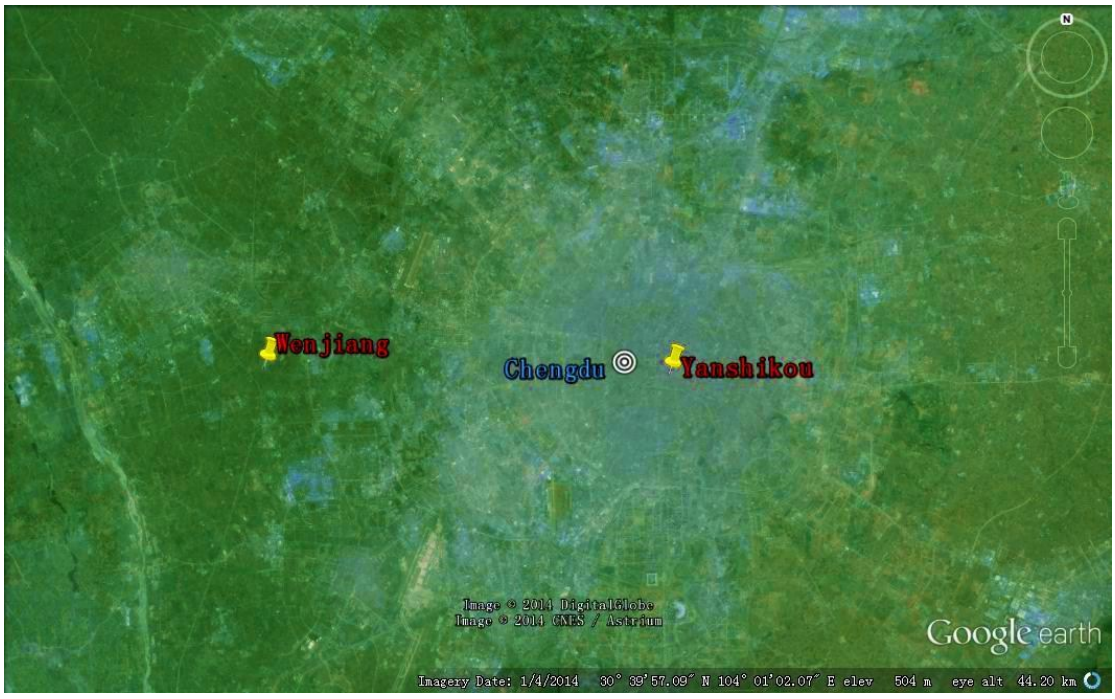


Figure 4 Test sites in Chengdu

3.2. Duration of monitoring

In order to intercept all emissions in the frequency bands, the monitoring time should be long enough. The measurement need to continue for more than 24 hours if the time distribution is unknown. Daily spectrum occupancy can be calculated by continuous monitoring during one week, and the results will be more comprehensive and accurate. So, in each test site, the measurement during of all test frequency bands will be continued for 24 hours/7 days.

3.3. Measurement equipment

The measurement equipment included antennas, spectrum analyzer and receiver, PC and other

accessories. The block diagram is shown in Figure 5.

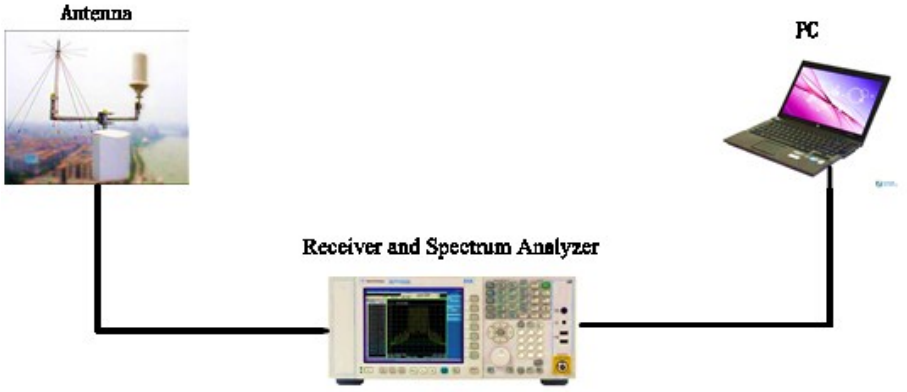


Figure 5 Connection diagram of measurement equipment

3.3.1. Antenna

Both the omnidirectional antenna and directional antenna were used for spectrum occupancy measurement. The parameters of measurement antennas are shown in Table 5.

Table 5 Parameters of Antenna

Band	Antenna type	Gain
40-3000MHz	omnidirectional	0-2dBi
3-6GHz	omnidirectional	0-3dBi
1-18GHz	directional	10dBi

3.3.2. Spectrum analyzer and receiver

Agilent N9030 and Rohde-Schwarz PR-100 are used, which are convenient to be controlled by computer. Typical noise figure of N9030 and PR-100 are shown in

	Band	Typical noise figure
Agilent N9030	10-2100 MHz	10dB
	2100-3600 MHz	12dB
	3500-8400 MHz	10dB
Rohde-Schwarz PR-100	20-3500 MHz	10dB
	3500-7500 MHz	18dB

3.3.3. Computer and control software

The computer was used to control the spectrum analyzer and receiver, collect and store the data output from the measurement instrument. The disk space should be more than 100 GB, and mobile storage mediums are needed aiming at data export.

3.3.4. Accessories

Accessories included low gain-loss cable, adapter, vehicle inverter, antenna bracket, net cable, GPIB line, etc.

3.4. Parameters setting

3.4.1. Resolution Bandwidth

The resolution bandwidth (RBW) of measurement equipment should not greater than the channel space in the measured band. During the test, different RBW were set up due to different measurement equipment.

1) If a standard monitoring receiver equipped with channel filter, RBW will not be greater than the narrowest channel space, in usual a smaller bandwidth will be suggested.
2) If a sweeping spectrum analyzer equipped with Gaussian or CISPR filter is used, RBW will be no larger than the 1/10 of the narrowest channel space in the band.

3) If the spectrum is calculated in FFT, RBW will equal to the narrowest channel space. In this case, however, the frequency must equal to the center frequency. Beyond such condition, the space between adjacent frequencies must be smaller than the 1/2 of the narrowest channel space in the band.

In view of instruments used in this measurement, i.e. spectrum analyzers and receiver, RBW is smaller than the 1/2 of the narrowest channel space in the band. RBW is set to the same value when taking measurements in different bands with the same antenna, which will improve the efficiency. RBW in each band is shown in Table 6.

Table 6 RBW of each band

Band(MHz)	**Typical Operating Systems**	**Typical System Bandwidth**	**Antenna Type**	**RBW (kHz)**
470-790	Analog/Digital TV	8	20-3000MHz omnidirectional	100
	Microwave relay communication system	1/2/4/8		
1300-1527	Meteorological Radar	10/20/75		
	Hydrogen spectral lines observing system	27		
	Microwave relay communication system	1/2/4/8		
	MSS			
	UAS(civilian)			
	Digital trucking private network	20		
2700-2900	Primary radar	5/10/15/30		
	Meteorological			
3300-3400	Wireless access(center station)	3	3-6 GHz omnidirectional	1000
	Radar			
3400-3700	Wireless access(center station)	3.5/40		
	Earth station			
3700-4200	Microwave relay communication system	30/40		
	Earth station			
4400-4500	Microwave relay communication system	40		
4800-4900	Microwave relay communication system	40		

3.4.2. Revisit time

Revisit time = (Observing time × Numbers of channel) + processing time.

Observing time depends on sweeping speed. Processing time is time for data transmission between the receiver and the controller.

According to Recommendations ITU-R SM. 1880, the revisit time should be smaller than 12 seconds, to ensure instant signal can be detected. If the revisit time is larger than 12 seconds, the occupancy measurement will be severely affected.

In order to reduce the revisit time of measurement instrument, numbers of scan channel

should be reduced. The number of scan channel is shown in Table 7, with which the revisit time are all smaller than 12 seconds.

Table 7 Number of scan channel

Band(MHz)	Antenna Type	Test bandwidth（MHz）	RBW（kHz）	Number of scan channel	
470-790	20-3000MHz omnidirectional	747 MHz	100	3201	7473
1300-1527				2271	
2700-2900				2001	
3300-3400	3-6 GHz omnidirectional	1190 MHz	500	1801	2383
3400-3700					
3700-4200					
4400-4500				201	
4800-4990				381	

3.4.3. Threshold

Threshold is a specified level to determine the channel was occupied or not. It could be a fixed value, preset value or a variable value, which have great influence on occupancy measurement.

Receivers have specified sensitivity and bandwidth, a preset threshold can provide accurate occupancy. The general setup is the smallest necessary field strength or receiver sensitivity plus the smallest S/N prospered for the specified service.

4. Measurement results

The measurement results include average frequency band occupancy during one week of each band in every measurement site, combined with spectrograms of some bands.

Frequency ranges 3700-4200MHz and 3400-3700MHz are allocated to satellite communication as C-band and extension of C-band respectively, they are mainly used in the fixed-satellite service, and the spectrum occupancy in both bands will be illustrated according to the spectrum usage of the existing satellite systems. The frequency occupancy of FSS in the band 3400-4200MHz is presented accordingly.

While the measurement results in section 4.1 to 4.11 represent the time occupancy of each band, for FSS in section 4.12 it describes how much spectrum occupied during test period.

4.1. 470-566 MHz

4.1.1. Beijing

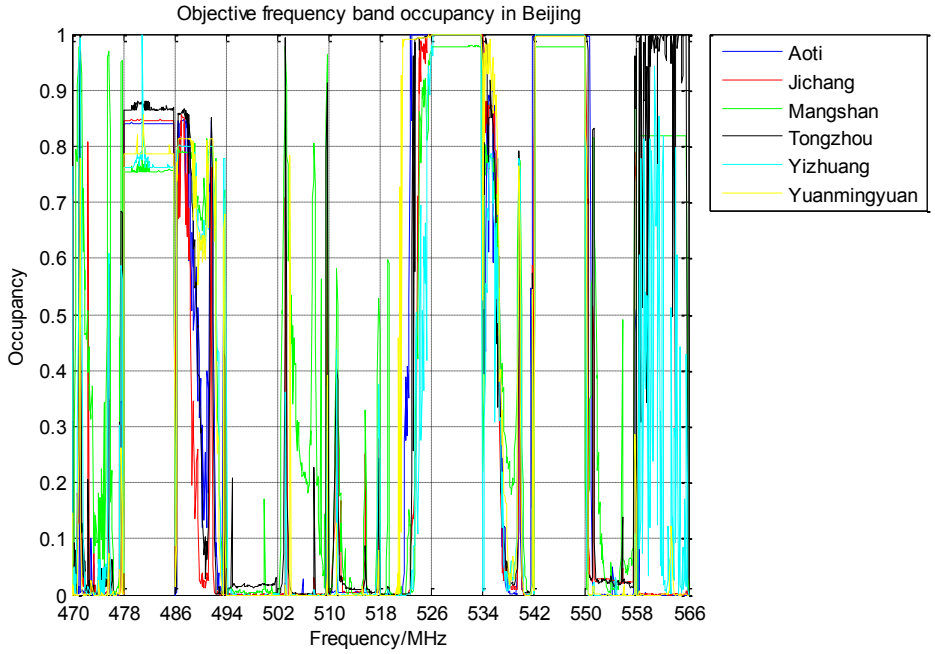


Figure 6 Average occupancy of band 470-566MHz in Beijing

Multiple analog and digital television broadcasting stations are operating in this band with relatively high occupancy in Beijing.

4.1.2. Shenzhen

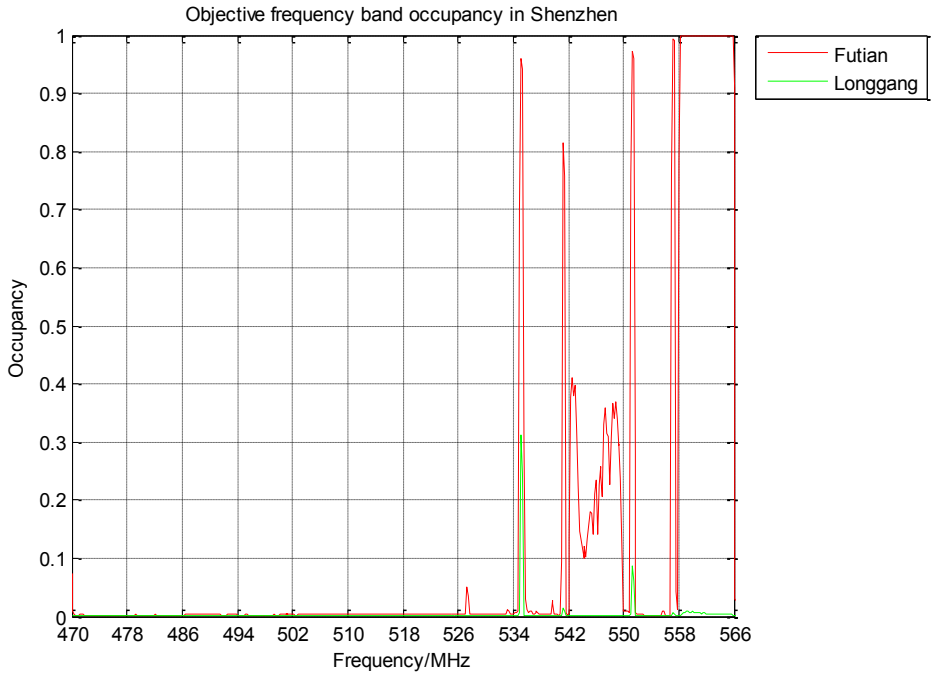


Figure 7 Average occupancy of band 470-566MHz in Shenzhen

Several channels are being used by analog and digital television broadcasting stations in Shenzhen.

4.1.3. Chengdu

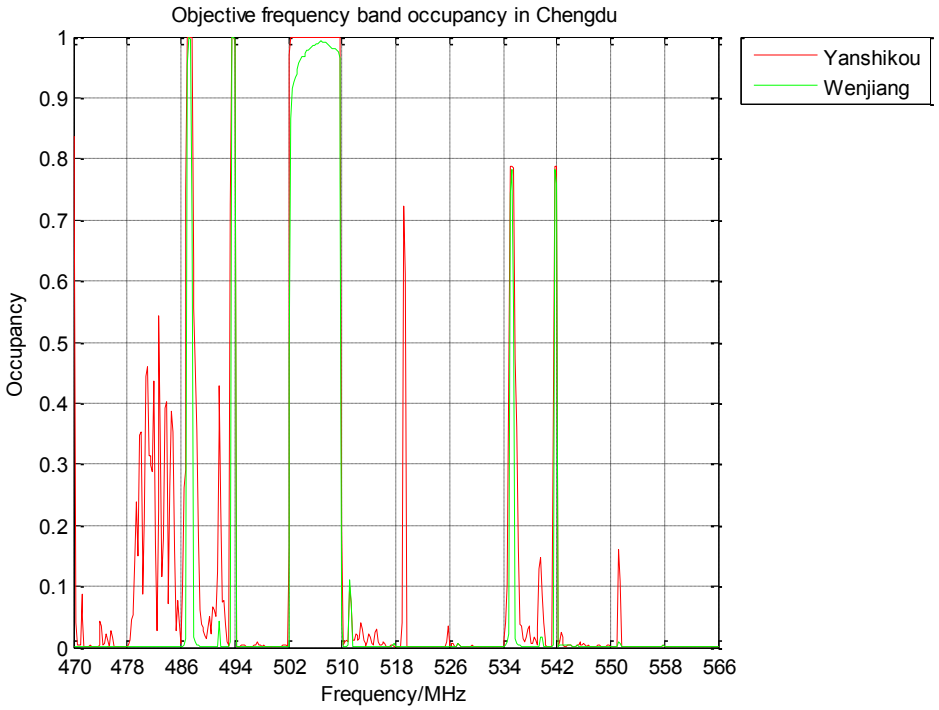


Figure 8 Average occupancy of band 470-566MHz in Chengdu

Figure 8 shows the spectrum occupation of this band which are being used by analog and digital television broadcasting stations in Chengdu.

4.2. 606-790 MHz

4.2.1. Beijing

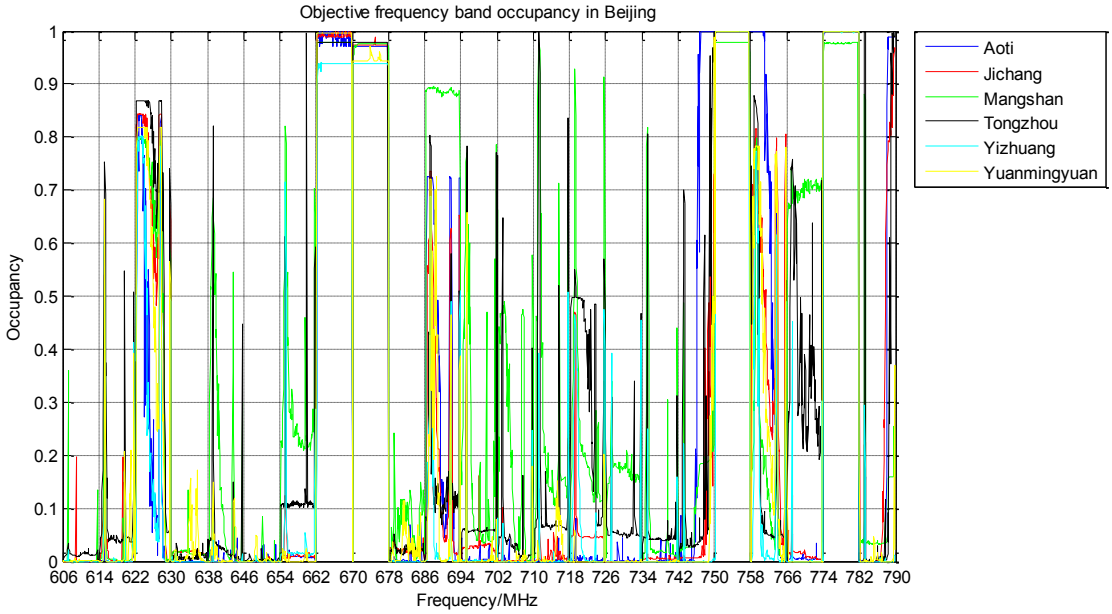


Figure 9 Average occupancy of band 606-790MHz in Beijing

Multiple analog and digital television broadcasting stations are operating in this band with relatively high occupancy in Beijing.

4.2.2. Shenzhen

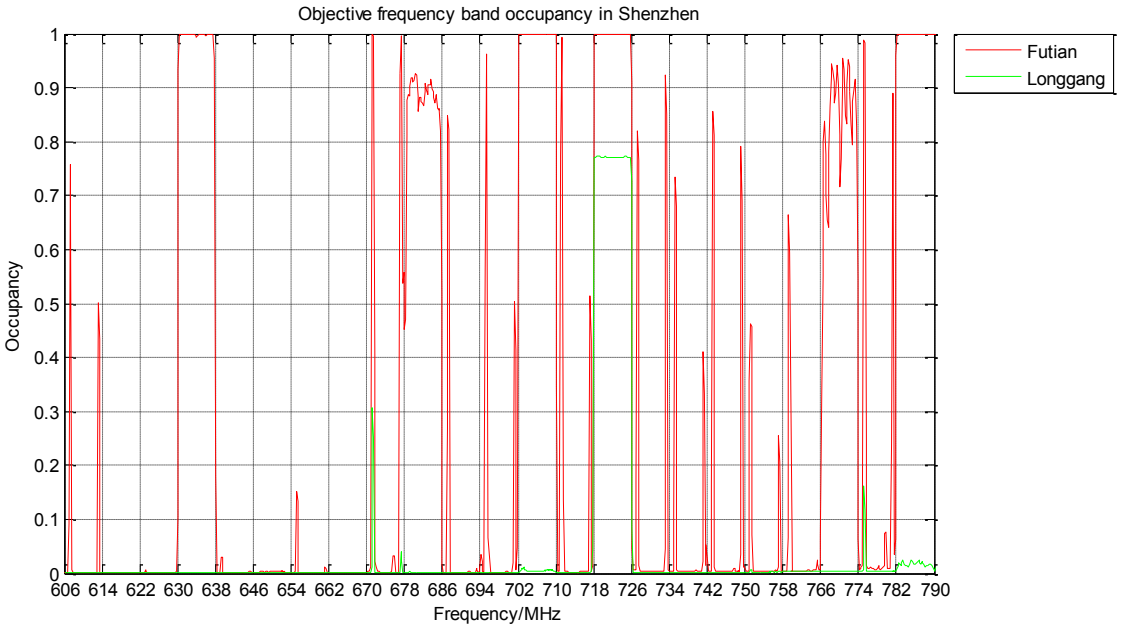


Figure 10 Average occupancy of band 606-790MHz in Shenzhen

Several channels are being used by analog and digital television broadcasting stations in Shenzhen.

4.2.3. Chengdu

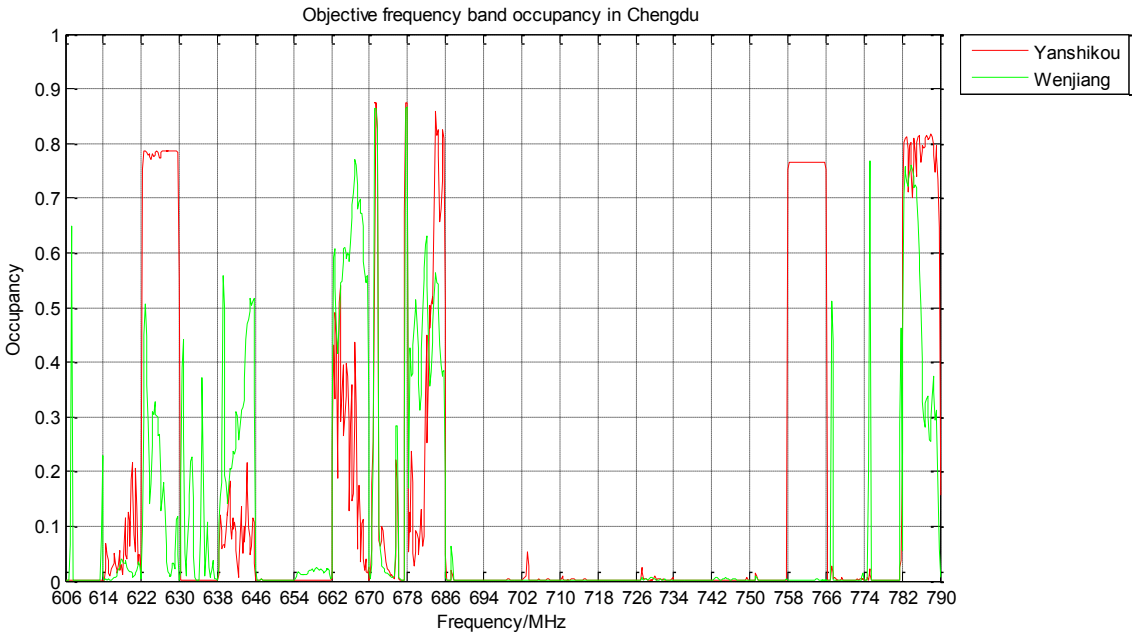


Figure 11 Average occupancy of band 606-790MHz in Chengdu

Except for band 694-758 MHz, most of spectrum of band 606-790 MHz is being occupied in Chengdu.

4.3. 1300-1400 MHz

4.3.1. Beijing

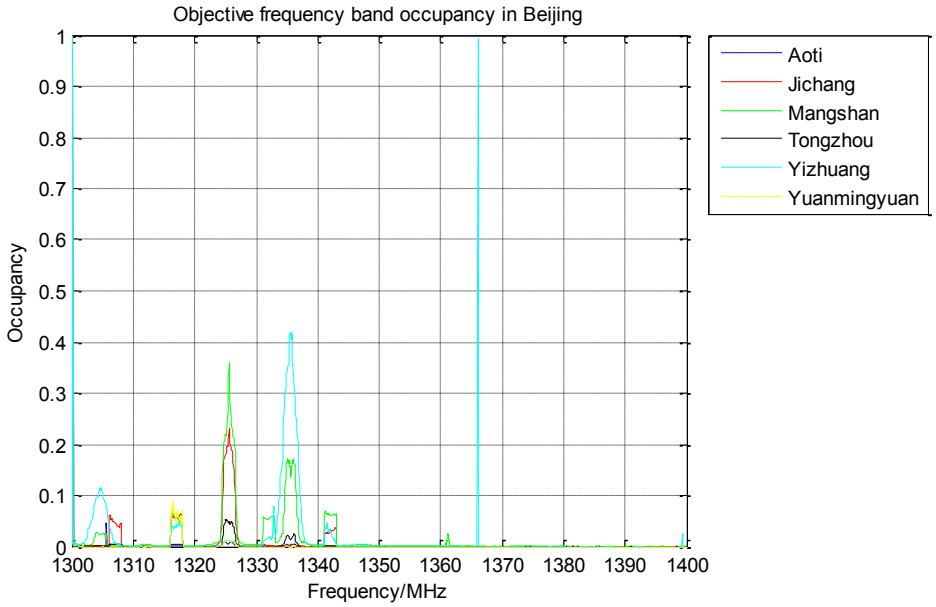


Figure 12 Average occupancy of the band 1300-1400MHz in Beijing

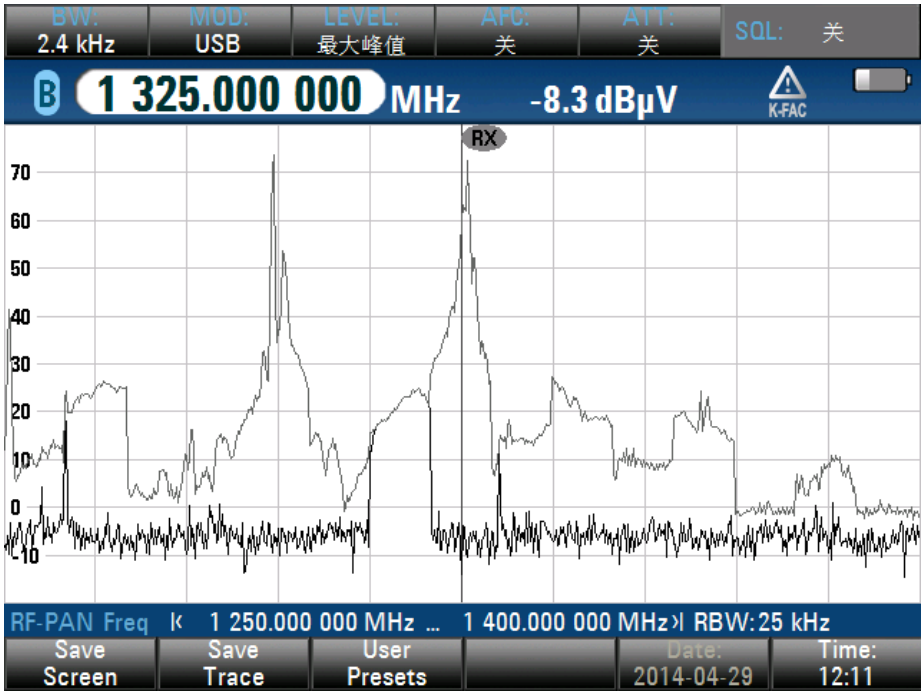


Figure 13 Spectrogram of 1250-1400MHz

Several radars are operating in the band 1300-1400 MHz with high occupancy in Beijing.

4.4. 1400-1427 MHz

4.4.1. Beijing

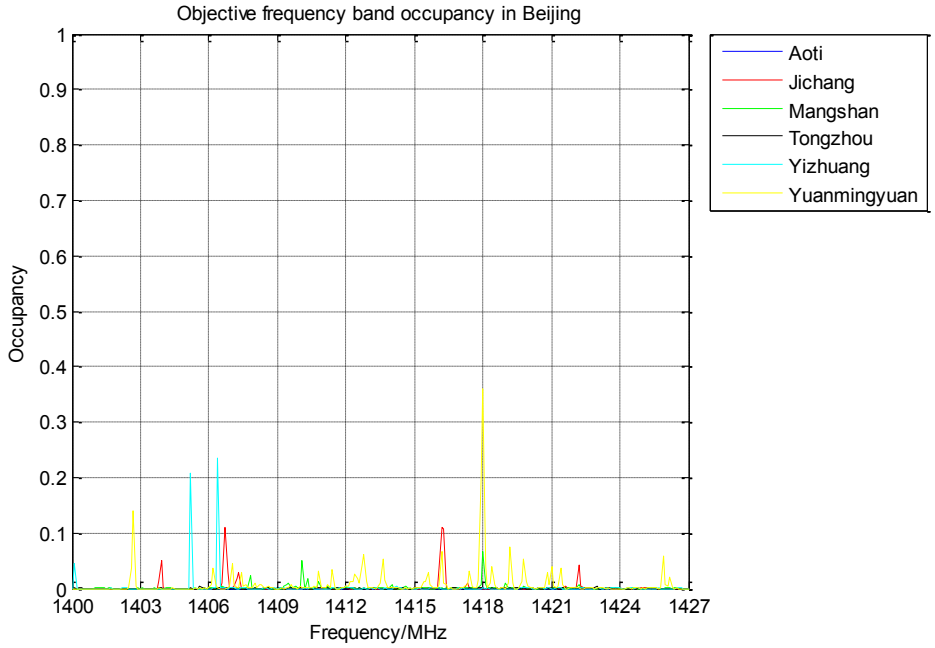


Figure 14 Average occupancy of band 1400-1427MHz in Beijing

Frequency occupancy of band 1400-1427 is relatively low, considering no transmission is allowed in this band.

4.5. 1427-1527 MHz

4.5.1. Beijing

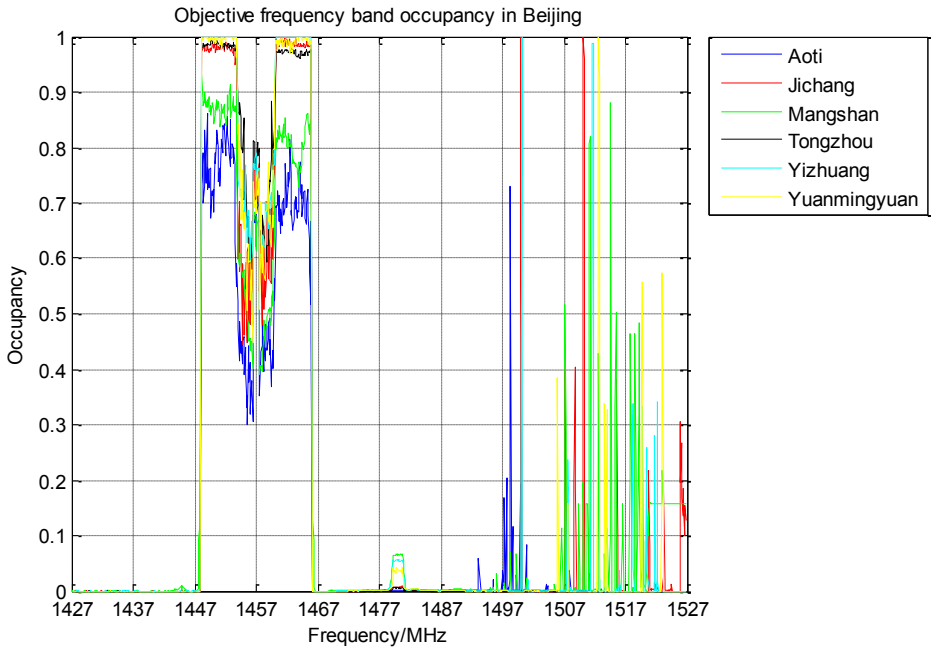


Figure 15 Average occupancy of band 1427-1527MHz during one week in Beijing

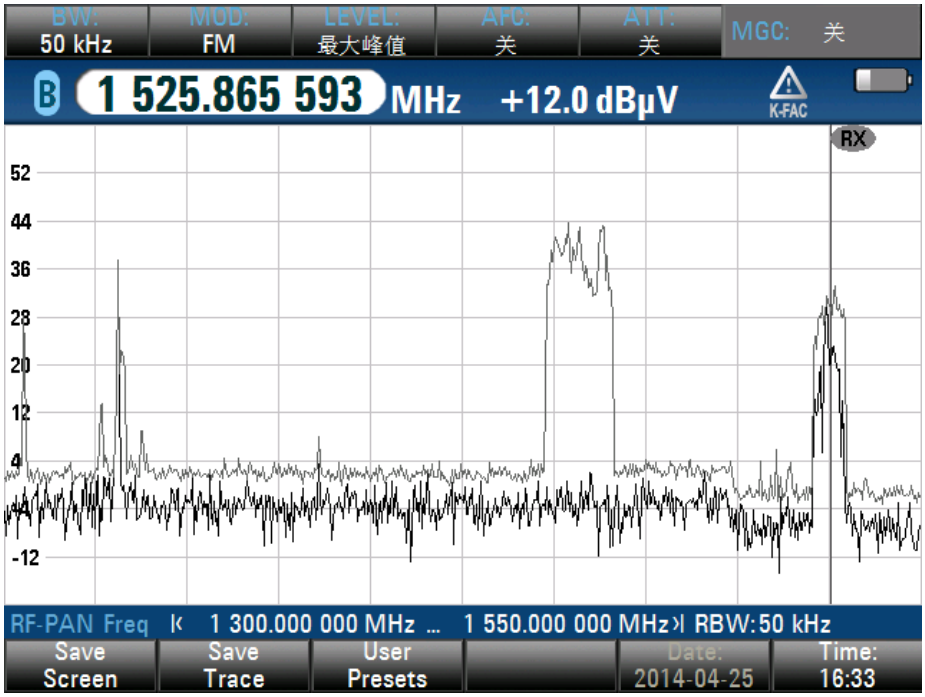


Figure 16 Spectrogram of 1300-1550MHz

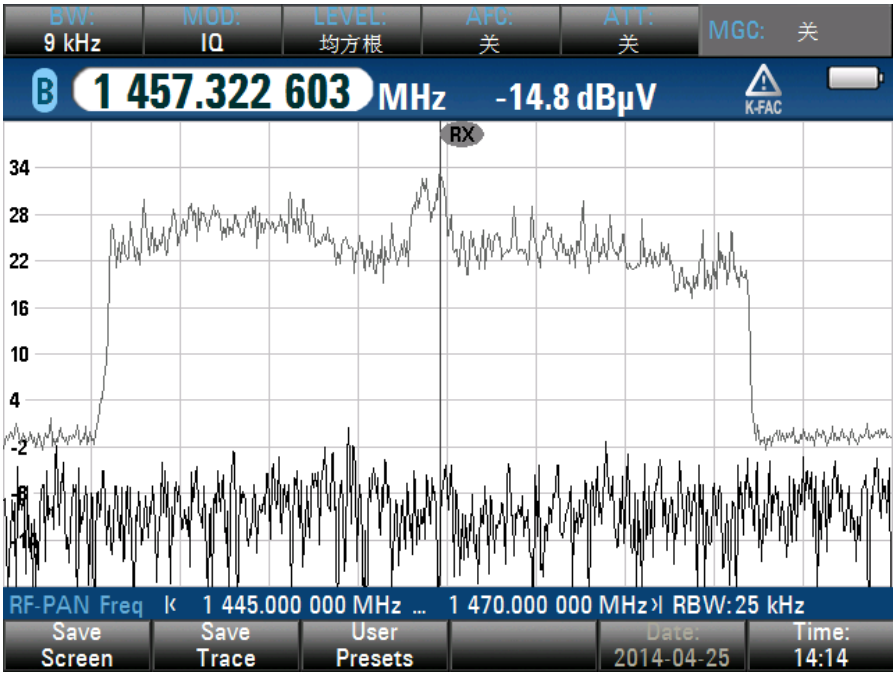


Figure 17 Spectrogram of 1445-1470MHz

Frequency occupancy of band 1447-1467 MHz is relatively high in Beijing, due to the private digital trucking systems operating in this band.

4.5.2. Shenzhen

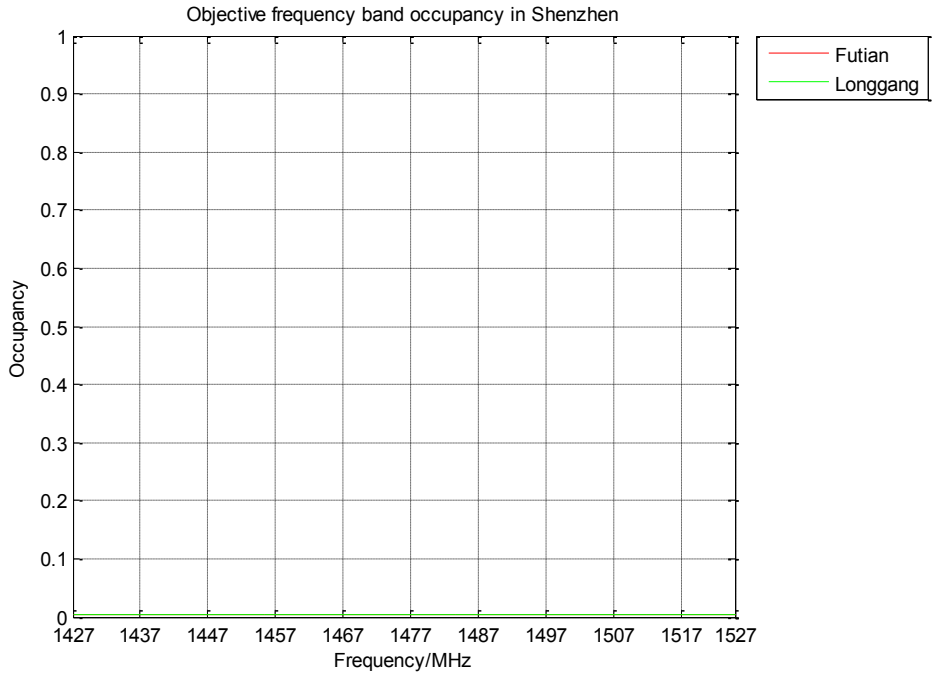


Figure 18 Average occupancy of band 1427-1527MHz during one week in Shenzhen

Frequency occupancy is extremely low in band 1427-1527 MHz at test sites in Shenzhen, where the trial network of private digital trucking systems is not deployed yet.

4.5.3. Chengdu

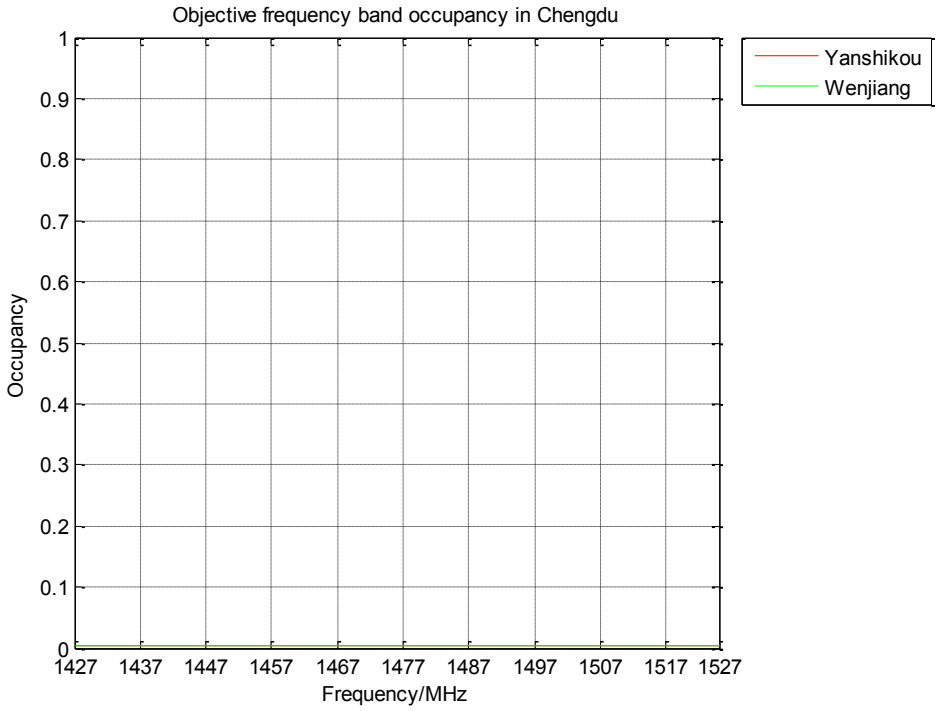


Figure 19 Average occupancy of band 1427-1527MHz during one week in Chengdu

Frequency occupancy is extremely low in band 1427-1527 MHz at test sites in Chengdu, where the trial network of private digital trucking systems is not deployed yet.

4.6. 2700-2900 MHz

4.6.1. Beijing

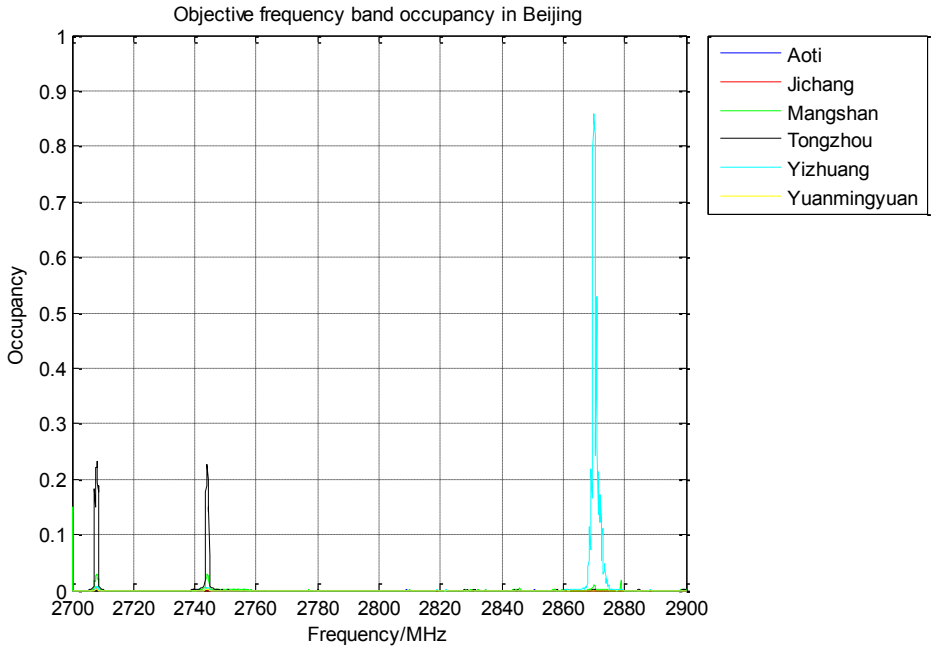


Figure 20 Average occupancy of band 2700-2900MHz during one week in Beijing

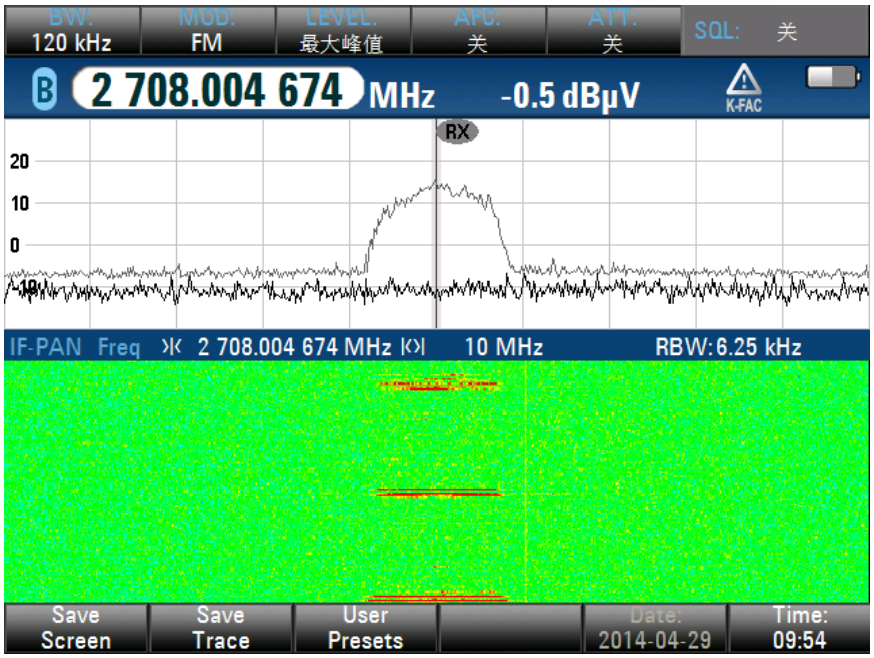


Figure 21 Spectrogram of 2703-2713MHz

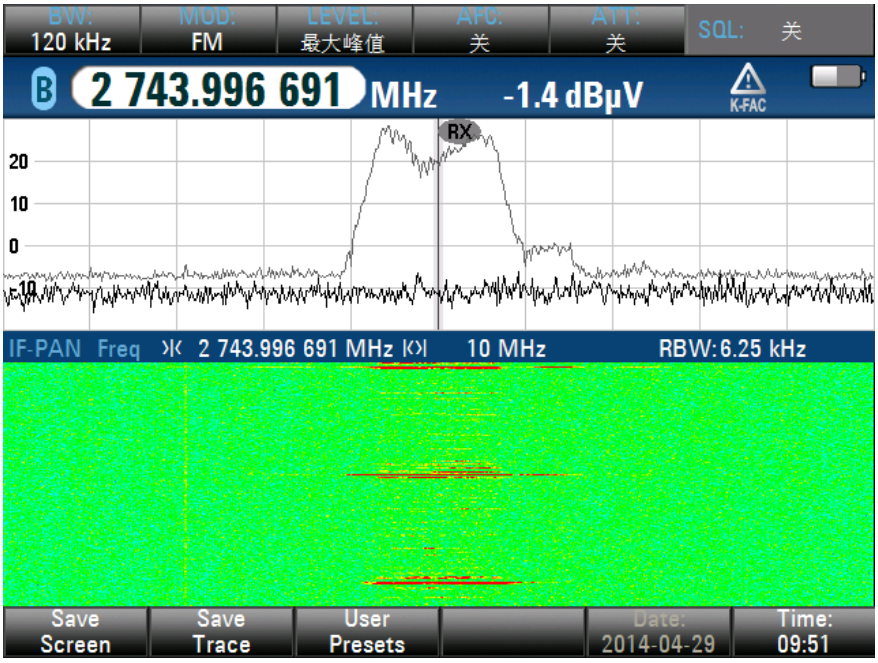


Figure 22 Spectrogram of 2733-2753MHz

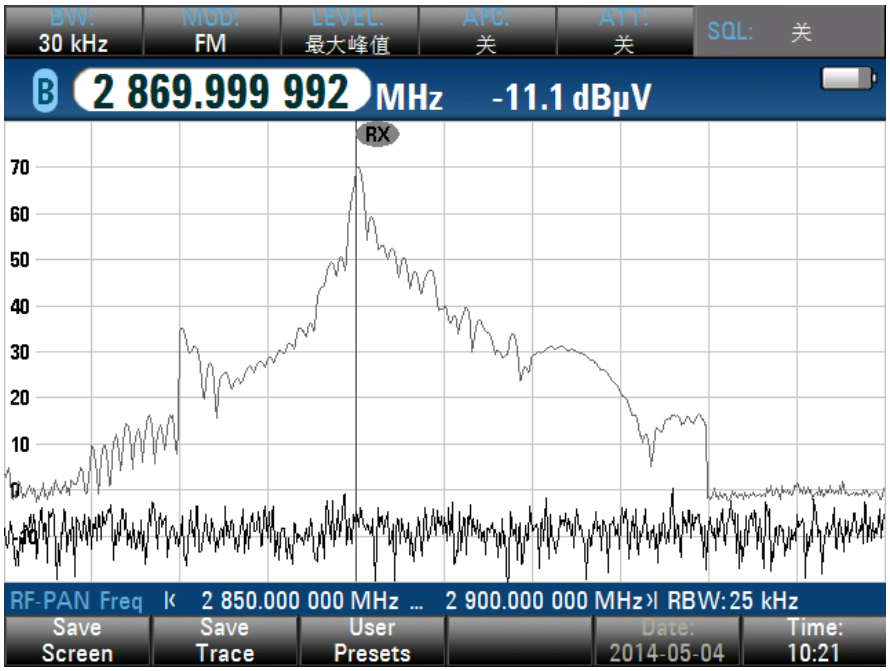


Figure 23 Spectrogram of 2850-2900MHz

Several radars are operating in band 2703-2713 MHz, 2733-2753 MHz and 2850-2900 MHz with high occupancy, as well as radar operating at 2780 MHz, with occupancy nearly 0.9.

4.6.2. Shenzhen

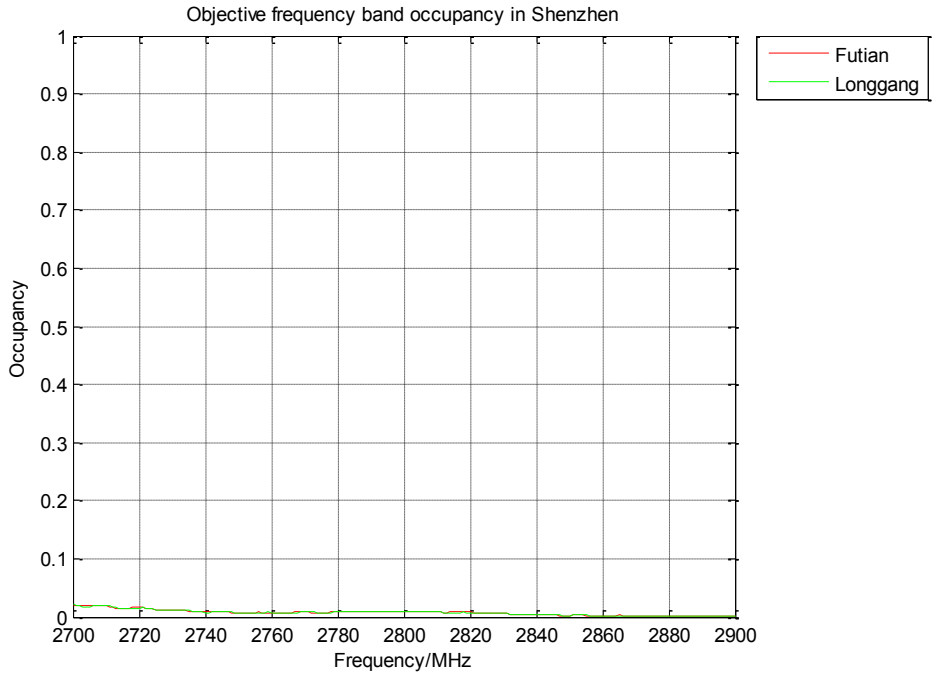


Figure 24 Average occupancy of band 2700-2900MHz during one week in Shenzhen

Frequency occupancy is extremely low in band 2700-2900 MHz at test sites in Shenzhen, which is outside of radar coverage.

4.6.3. Chengdu

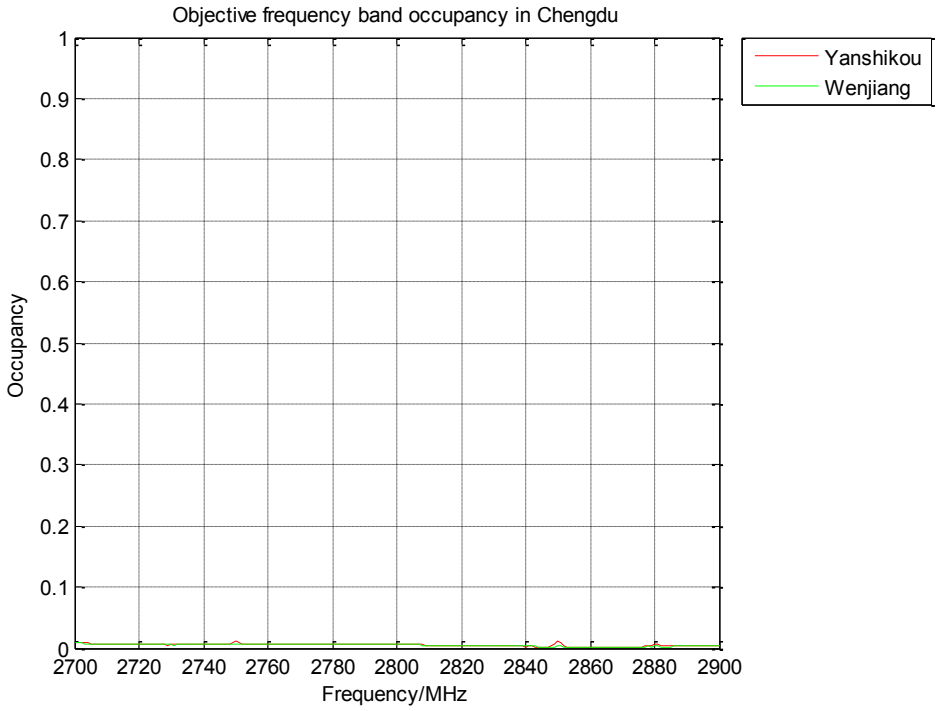


Figure 25 Average occupancy of band 2700-2900MHz during one week in Chengdu

Frequency occupancy is extremely low in band 2700-2900 MHz at test sites in Chengdu, which is outside of radar coverage.

4.7. 3300-3400 MHz

4.7.1. Beijing

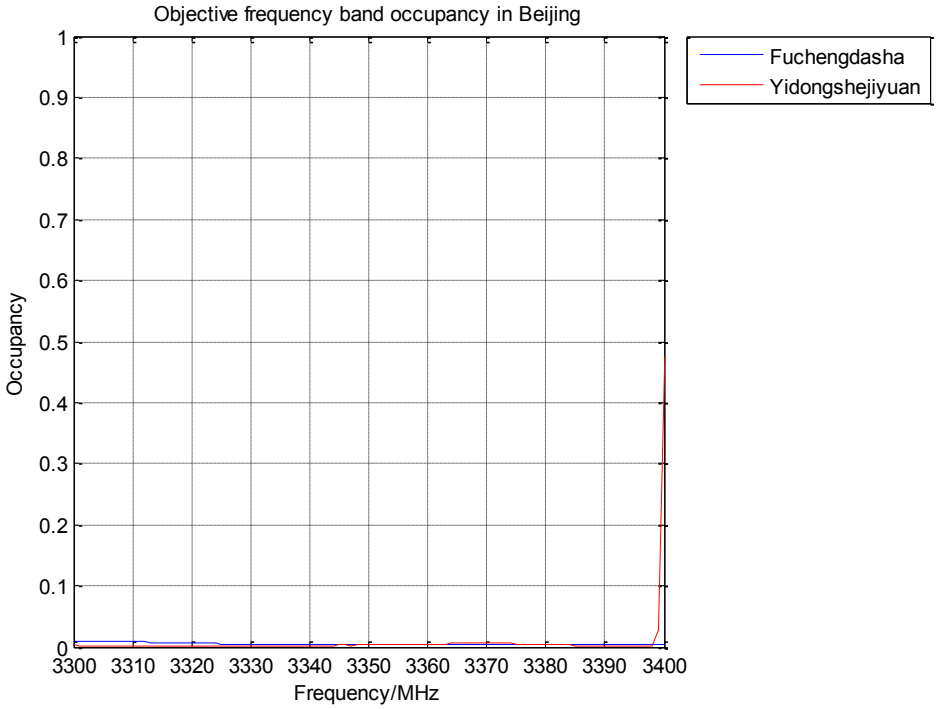


Figure 26 Average occupancy of band 3300-3400MHz during one week in Beijing

Frequency occupancy is extremely low in band 3300-3400 MHz at test sites in Beijing.

4.7.2. Shenzhen

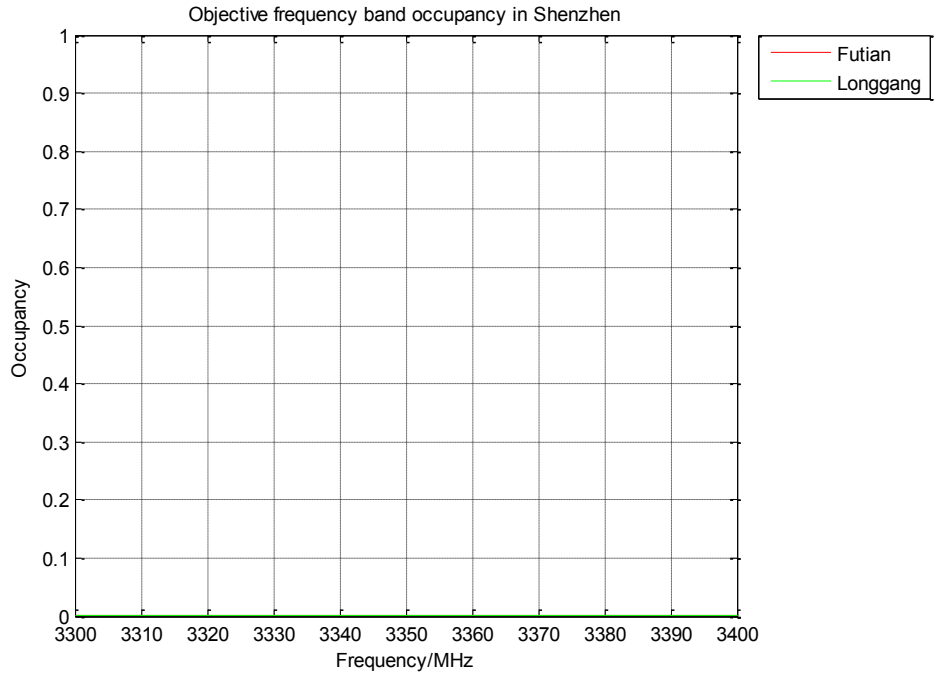


Figure 27 Average occupancy of band 3300-3400MHz during one week in Shenzhen

Frequency occupancy is extremely low in band 3300-3400 MHz at test sites in Shenzhen.

4.8. 3400-3700 MHz

4.8.1. Beijing

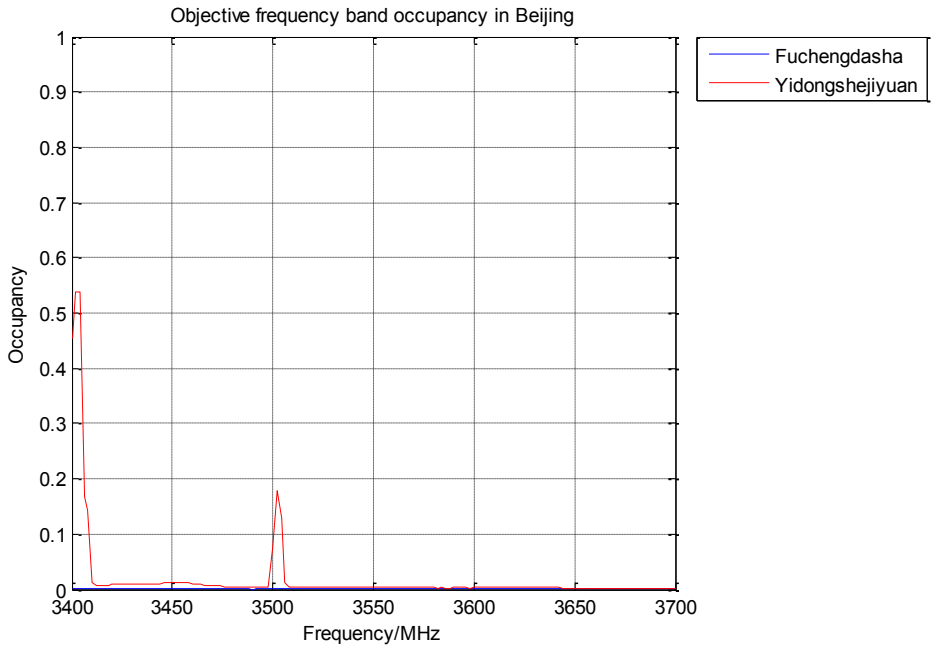


Figure 28 Average occupancy of band 3400-3700MHz during one week in Beijing

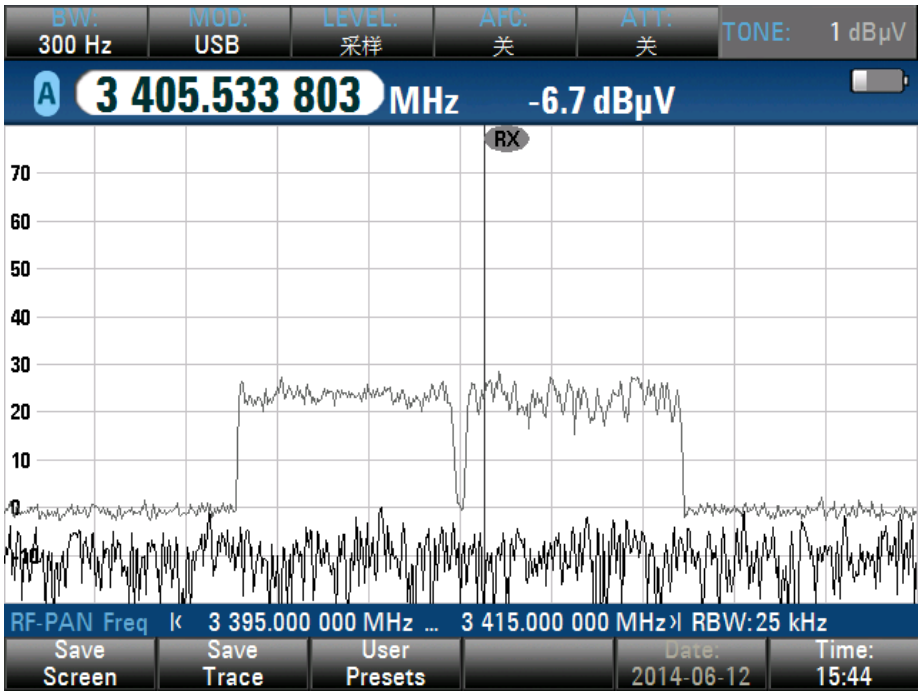


Figure 29 Spectrogram of 3395-3415MHz

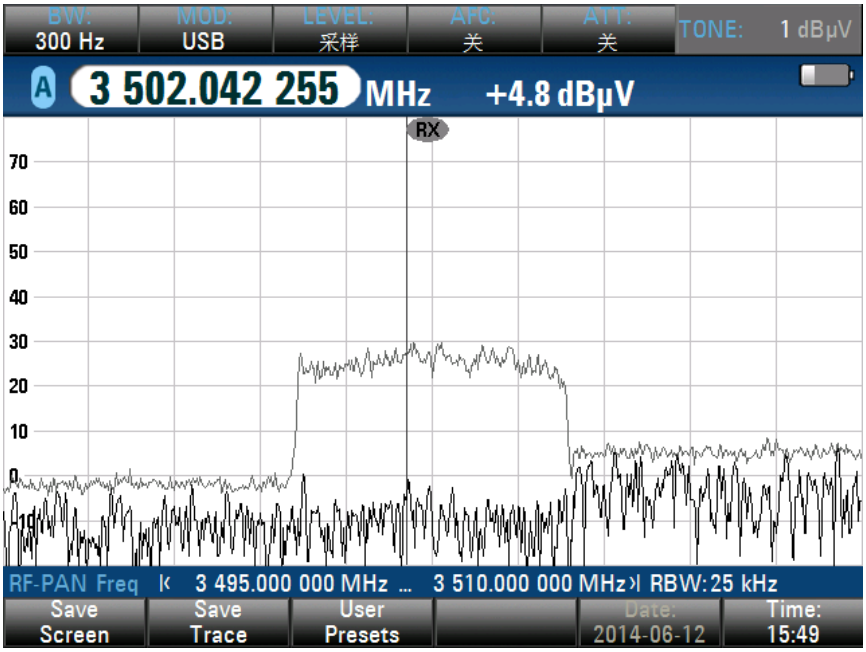


Figure 30 Spectrogram of 3495-3510MHz

Some wireless access stations are operating in band 3400-3700 MHz with high occupancy, such as one operating at 3405 MHz with occupancy over 0.5. Occupancy of FSS is provided in 4.12.

4.8.2. Shenzhen

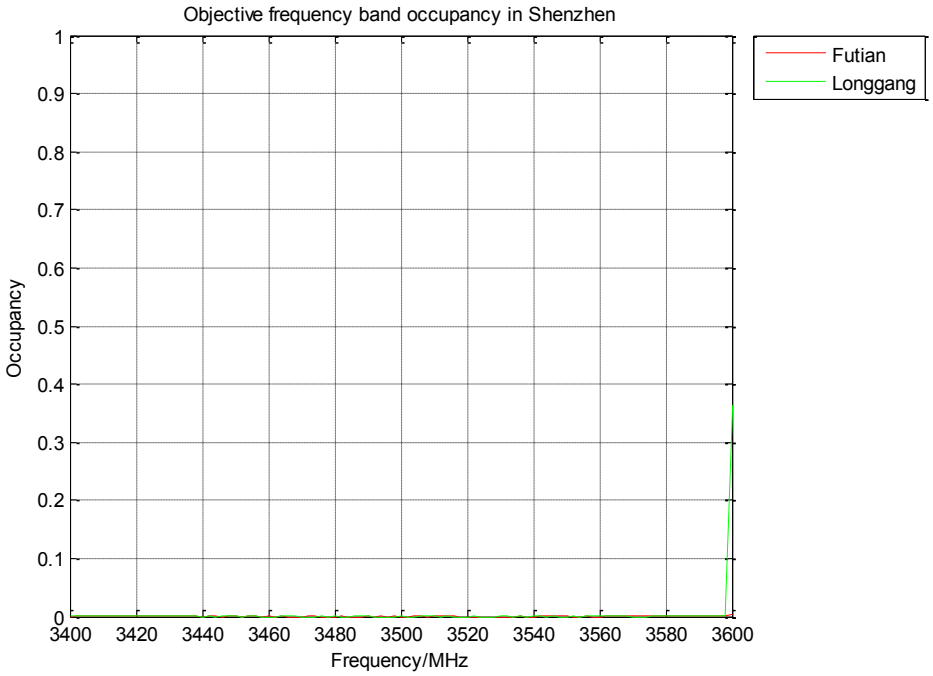


Figure 31 Average occupancy of band 3400-3600MHz during one week in Shenzhen

Frequency occupancy is extremely low in band 3400-3600 MHz at test sites in Shenzhen.

4.9. 3700-4200 MHz

4.9.1. Beijing

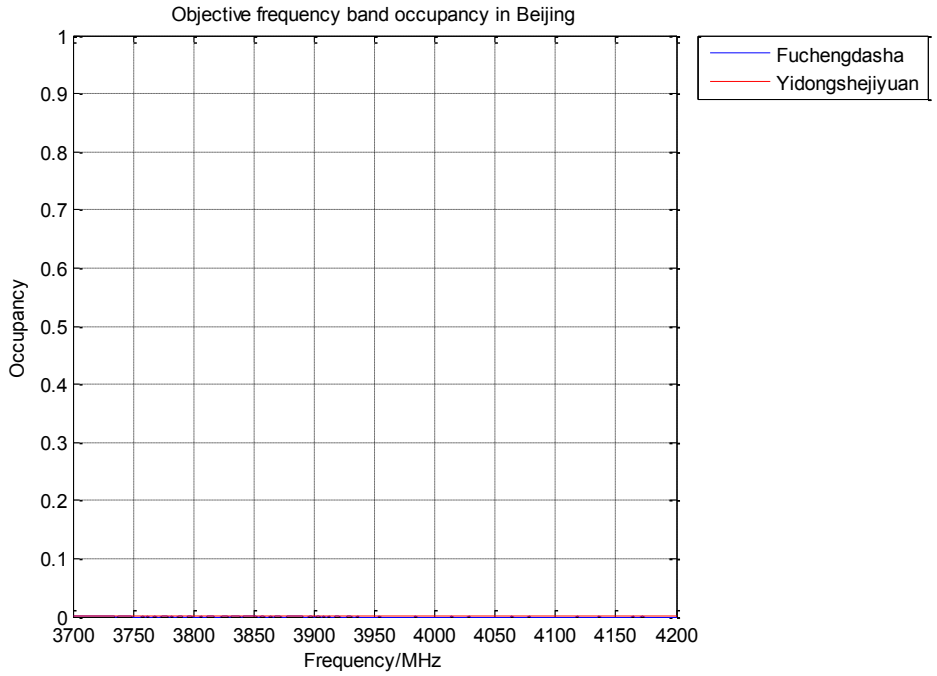


Figure 32 Average occupancy of band 3700-4200MHz during one week in Beijing

Frequency occupancy is extremely low in band 3700-4200 MHz at test sites in Beijing. Occupancy of FSS is provided in 4.12.

4.10. 4400-4500 MHz

4.10.1. Beijing

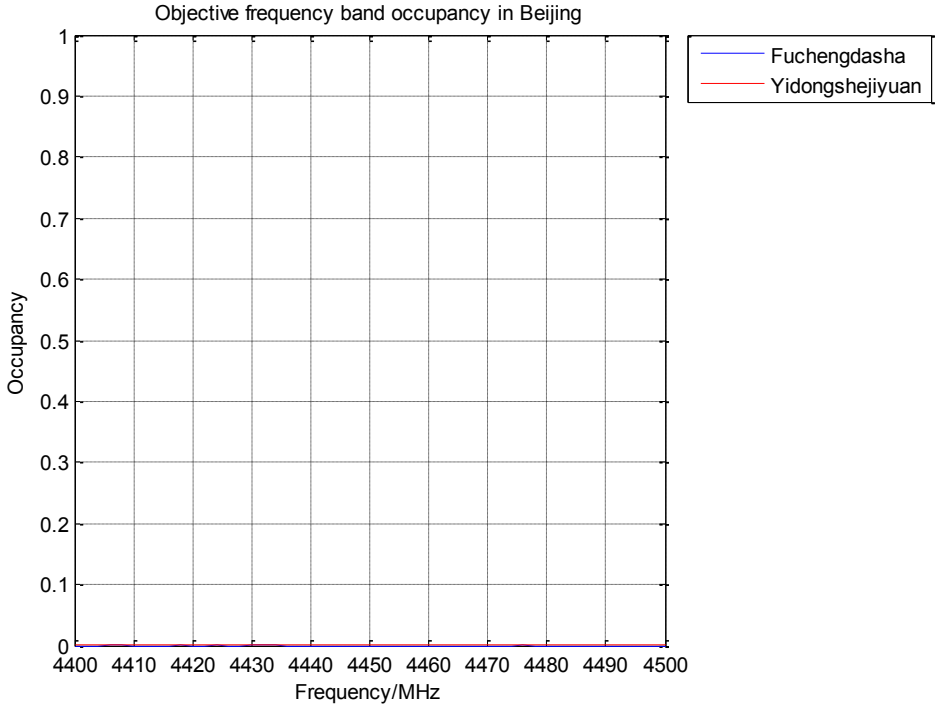


Figure 33 Average occupancy of band 4400-4500MHz during one week in Beijing

Frequency occupancy is extremely low in band 4400-4500 MHz at test sites in Beijing.

4.10.2. Shenzhen

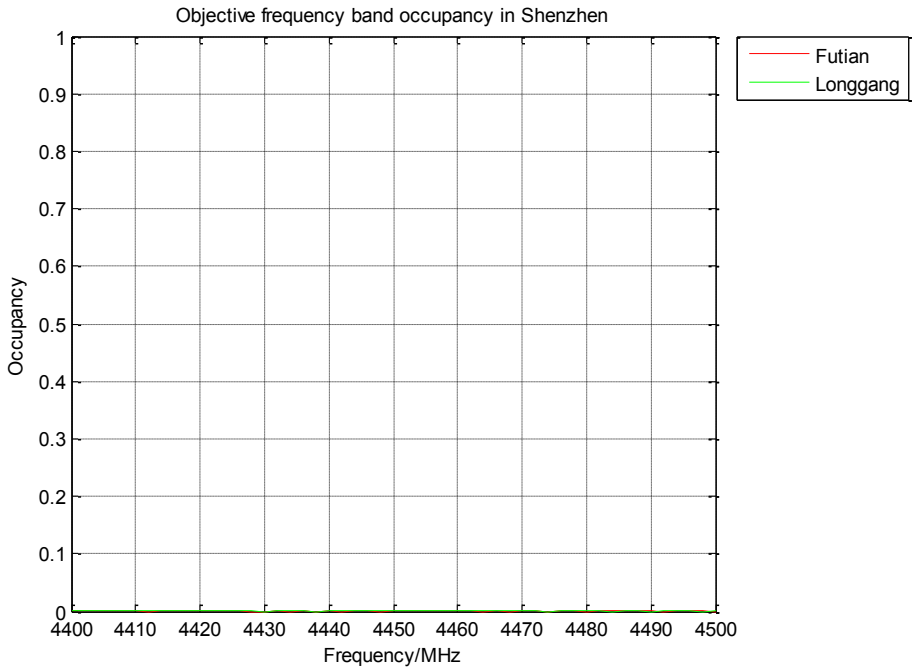


Figure 34 Average occupancy of band 4400-4500MHz during one week in Shenzhen

Frequency occupancy is extremely low in band 4400-4500 MHz at test sites in Shenzhen.

4.11. 4800-4990 MHz

4.11.1. Beijing

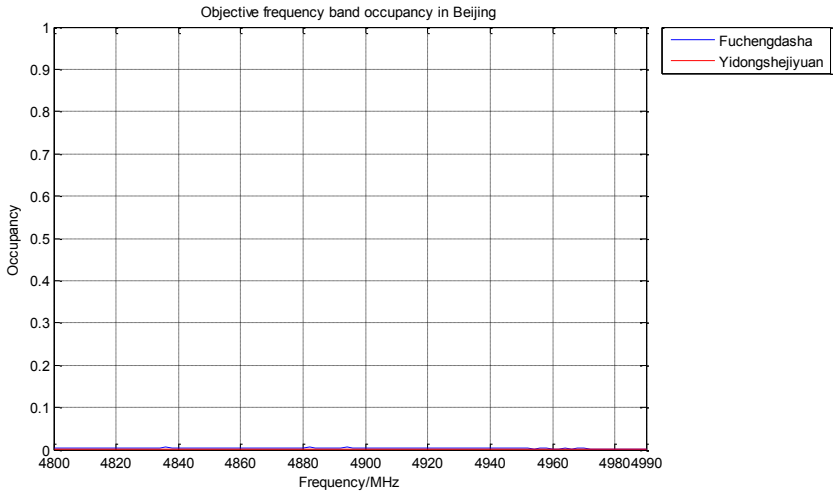


Figure 35 Average occupancy of band 4800-4990MHz during one week in Beijing

Frequency occupancy is extremely low in band 4800-4990 MHz at test sites in Beijing.

4.11.2. Shenzhen

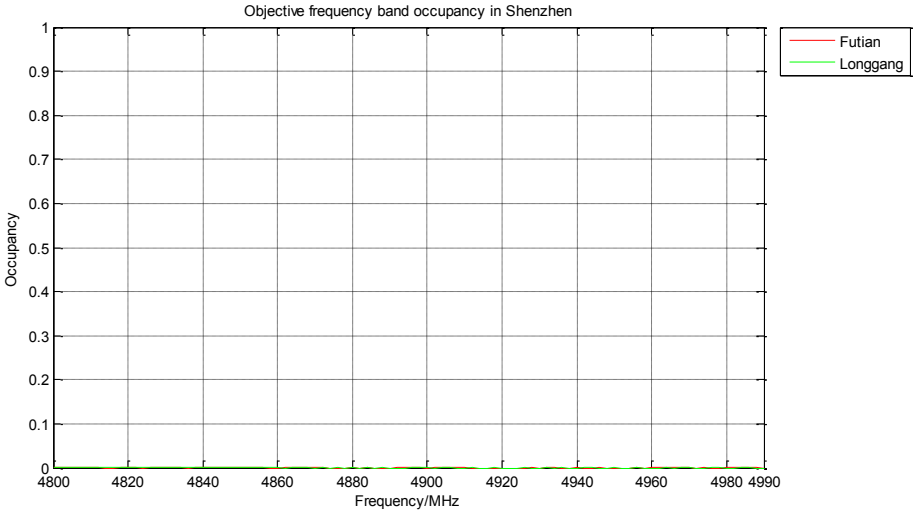


Figure 36 Average occupancy of band 4800-4990MHz during one week in Shenzhen

Frequency occupancy is extremely low in band 4800-4990 MHz at test sites in Shenzhen.

4.12. Frequency occupancy for FSS in the 3400-4200MHz frequency range

At present, dozens of communication satellites on geostationary orbits are already put into use by Chinese operators, which are all covering the territory of China for fixed-satellite service in the 3400-4200MHz frequency range. Based on the measurement in 2013, which was to measure how much spectrum occupied during test period, the average frequency occupancy of these satellites in the frequency band 3400-3700MHz and 3700-4200MHz are calculated respectively, which are 0.393 and 0.652. It indicates that 39.3% of extended C band and 65.2% of C band are occupied during test period. Figure 37 shows the frequency occupancy of each satellite in the 3400-3700MHz frequency range, slightly over half of which is below 0.5. Figure 38 shows the frequency occupancy of each satellite in the 3700-4200MHz frequency range, mostly of which is above 0.6.

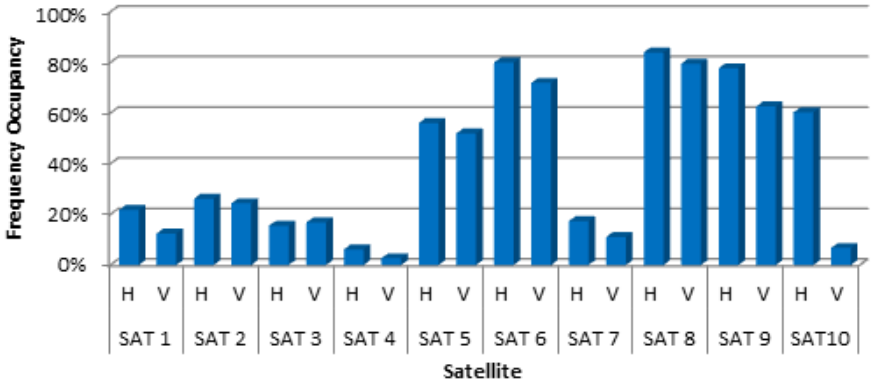


Figure 37 Frequency occupancy of band 3400-3700MHz for FSS

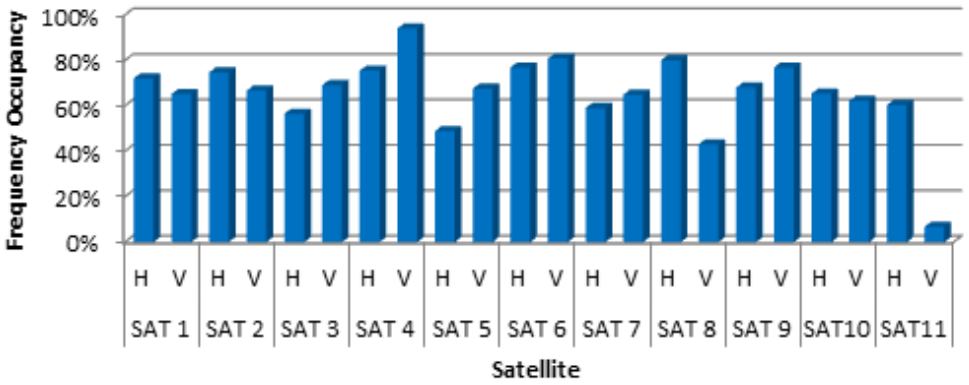


Figure 38 Frequency occupancy of band 3700-4200MHz for FSS

5. Assessments of spectrum resource usage

On the basis of the Section 4, the average frequency band occupancy is shown in Figure 39.

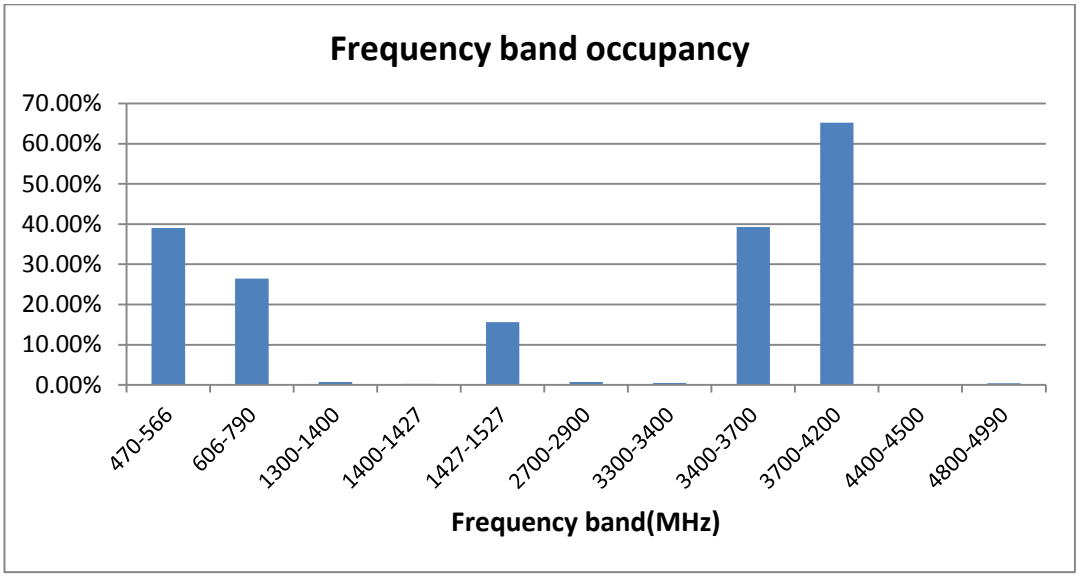


Figure 39 Frequency band occupancy

The occupancy of frequency band 3700-4200MHz is above 0.6, 470-566MHz and 3400-3700MHz slightly below 0.4, 606-790MHz above 0.2, 1427-1527MHz above 0.1, and the others are far below 0.1.

The results of frequency occupancy measurement should reflect the actual frequency usage depending on the choice of measurement sites. However, the traditional monitoring site network is not sufficient to know the usage of spectrum at every place, especially for the frequency band beyond 1GHz. In this case, incumbent radio stations and frequency sharing criterion should be taken into account for more effective and accurate assessment of spectrum usage.

The compatibility study results of sharing studies reports conducted by China and other administrations submitted to ITU-R study groups are considered and referred in this report. The geographic separation distance is the key issue to be considered for frequency sharing between new services/applications and incumbent radio stations, which reflect the actual situation of the usage of spectrum.

The most urgent spectrum requirement in the future stems from IMT/mobile broadband. WRC-15 agenda item 1.1 considers additional spectrum allocations to the mobile service on a primary basis and identification of additional frequency bands for IMT and related regulatory provisions, to facilitate the development of terrestrial mobile broadband applications, according to Resolution 233(WRC-12). Based on the input contributions submitted to ITU-R WP 5D, spectrum requirement prediction of IMT in some countries and worldwide are listed in Table 8.

Table 8 Spectrum requirement prediction of IMT

Region	Spectrum requirement prediction of IMT
USA	Additional 275 MHz by 2014
Australia	Total 1100 MHz by 2020
Russia	Total 1065 MHz by 2020
India	Additional 300 MHz by 2017, another 200 MHz by 2020
UK	Total 775-1080 MHz and 2230-2770 MHz for low and high user demand

	scenarios by 2020
China	Total 570-690 MHz by 2015, and 1490-1810 MHz by 2020
Global	Total 1340-1960 MHz by 2020

Some candidate frequency bands have been proposed by administrations in WP 5D and the JTG, including 470-790 MHz, 1300-1527 MHz, 2700-2900 MHz, 3300-4200 MHz, 4400-4500 MHz and 4800-4990 MHz. These candidate bands could be identified to IMT taken into account the compatibility sharing studies. The assessments and proposals of spectrum resource usage contained in the following section are results of evaluation considering frequency band occupancy measurement, incumbent radio stations and compatibility sharing studies.

5.1. 470-790MHz

Both the broadcasting service and fixed service are identified as primary service in this band. Analog television and digital television are the main incumbent radio systems in this band as well as microwave relay communication system being used in some region. As shown in Figure 39, average frequency band occupancy in band 470-566 MHz and 606-790MHz are more than 0.2, particularly in Beijing occupancy in band 470-566 MHz is nearly 0.4.

5.1.1. Analog television and digital television

The frequency band 470-790MHz is allocated to broadcasting service except for 566-606MHz, which divided into 35 TV channels. At the present time, China is experimenting transition from analog TV to digital TV. Thousands of broadcasting TV stations are in use all over the country, and the average frequency band occupancy is high in band 470-790MHz.

According to the document [5], in co-frequency scenario, the separation distance is at least 160km with 3 base stations and 200 km with multiple base stations in the case of IMT interfering with broadcast TV. In adjacent frequency scenario, the separation distance of IMT and broadcasting TV depends on the filter of IMT system, which is from 7 MHz to 21 MHz, and it depends on whether the IMT system is in the broadcasting service zone or not.

5.1.2. Microwave relay communication system

Hundreds of microwave relay stations are still in use in the band 470-790MHz. According to document [6], in the scenario of interference from IMT base station into FS receive station, separation distances of co-channel range from 25 kilometers to 217 kilometers in the urban, suburban and rural environment. Separation distances of adjacent channel could exceed 30 kilometers depending on the frequency separation and the FS pointing direction.

For band 470-790 MHz, spectrum usage is extensive with large amount of stations in use, and the requirement of spectrum sharing between existing and new services/applications is rigorous. However, there is still underutilized spectrum in some regions, such as band 694-790 MHz in Chengdu.

5.2. 1300-1527MHz

Radiolocation service, broadcasting-satellite service and mobile service are allocated on a primary basis, of which typical systems are radar, BSS and Unmanned Aeronautical Systems (UAS).

5.2.1. Radar

The frequency band 1300-1350 MHz is allocated to aeronautical radionavigation, radiolocation and radionavigation-satellite (earth to space) service, and frequency band 1350-1400 MHz is allocated to radiolocation service. Radar is the typical radio system in portions of the frequency band 1300-1400 MHz. Dozens of radar stations are operating in China within the frequency band 1300-1400 MHz, with a relatively high frequency band occupancy.

Separation distances between IMT and radar system in co-channel operation are several hundreds of kilometers in the frequency band 1300-1400 MHz according to document [7]. For non-co-channel operation, separation distances are reduced significantly and with some mitigation techniques, such as allocating guard band, improving RF and filter performance of the IMT base station and adjusting down tilt of base station antennas. This could be even further reduced if front-end filters were added to the radar receivers. Document [8] points out that radionavigation radars contain wide geographic coverage, due to its technical characteristics defined by the missions.

5.2.2. Broadcasting satellite service

The frequency band 1467-1492 MHz is allocated on a primary basis to the broadcasting satellite service in China. China Satcom has declared and planned to operate BSS system in this band. One satellite will be launched next year to provide BSS in this band.

Sharing and compatibility requirement between BSS and IMT in urban, suburban and rural environment are illustrated in document [9]. To avoid interference from BSS into IMT base station, isolation should be at least 1.85 dB, 2.46 dB and 4.64 dB in co-channel operation and all 0 dB in adjacent channel operation. To avoid interference from BSS into IMT UE, isolation could be 0 dB in both co-channel and adjacent channel operation. To avoid interference from IMT base station into BSS, separation distance should be at least 6.32 km, 12.01 km and 15.17 km in co-channel operation, as well as 0.561 km, 1.136 km and 2.043 km in adjacent channel operation. To avoid interference from IMT UE into BSS, separation distance should be at least 0.08 km, 0.1 km and 0.05 km in co-channel and all 0 km in adjacent channel operation.

5.2.3. Mobile service

The frequency band 1427-1525MHz is allocated on a primary basis to the mobile service, and aeronautical mobile service is allowed to operate in this band except for band 1427-1429MHz. The frequency band 1447-1467 MHz will be assigned to private digital trunking system using LTE technology in China. The trial network has been established in some cities and will be deployed countrywide. Meanwhile, Chinese administration is planning to identify the frequency band 1430-1446 MHz to unmanned aeronautical system (UAS).

According to document [10], in the rural environment, the separation distance in co-frequency scenario should be at least 194 km between IMT base station and aeronautical telemetering land station, while beyond line-of-sight between IMT base station and aeronautical telemetering mobile station. The separation distance with 5 MHz frequency separation scenario should be at least 22.7 km between IMT base station and aeronautical telemetering land station, while 15 km between IMT base station and aeronautical telemetering mobile station. The separation distance with 10 MHz frequency separation case should be at least 15 km between IMT base station and aeronautical telemetering land station, while 5 km between IMT base station and aeronautical telemetering mobile station. In the suburban environment, the separation distance in co-frequency case should be at least 177 km between IMT base station and aeronautical telemetering land station, while beyond line-of-sight between IMT base station and aeronautical telemetering mobile station.
Above all, the separation distance in co-frequency case is beyond line-of-sight between IMT and UAS.

In the frequency ranges 1300-1527 MHz, BSS and UAS will be deployed in China. Considering that band 1400-1427 is not allowed to transmit globally, there is very few available spectrum in band 1300-1527 for new services/applications in the future.

5.3. 2700-2900MHz

The frequency band 2700-2900 MHz is allocated on a primary basis to aeronautical

radionavigation and radiolocation service, of which typical systems are radar. Hundreds of air surveillance radars and meteorological radars are in operation in the frequency band 2700-2900 MHz with relatively higher frequency band occupancy. For example, frequency occupancy of the meteorological radar in Beijing operating at 2870 MHz is beyond 0.9.

For co-channel operation or cross border co-ordination purpose according to document [11], the required separation distance between IMT and radar system for typical land propagation are 123 km to 324 km with an interference bandwidth of 5 MHz or 10 MHz and 99 km with an interference bandwidth of 20 MHz. The required separation distances taking tropospheric scatter or propagation over sea area into consideration are 488 km to 783 km with an interference bandwidth of 5MHz or 10MHz. For adjacent-channel operation, separation distances could be reduced significantly with some mitigation techniques, such as allocating guard band, improving RF and filter performance of the IMT base station and adjusting down tilt of base station antennas.

For band 2700-2900 MHz, occupancy of some incumbent radars are relative high and criteria of spectrum sharing is stringent.

5.4. 3300-3400MHz

The frequency band 3300-3400 MHz is allocated to on a primary basis to radiolocation with relatively low frequency occupancy and dozens of licensed stations.

According to document [12], for outdoor environment, separation distances between IMT UE and land-based radar are 0.075 km to 213 km in co-channel operation and 0.07 km to 80 km in adjacent channel operation; for indoor environment, separation distances between IMT UE and land-based radar are 0.07 km to 130 km in co-channel operation and 0.07 km to 32 km in adjacent channel operation. Separation distances between IMT system and radar system could be reduced with the mitigation measures such as increasing protection bandwidth and improving RF performance.

For band 3300-3400 MHz, existing usage of spectrum is low with relatively low frequency occupancy and a small amount of incumbent station, and the requirement of spectrum sharing is less stringent.

5.5. 3400-4200 MHz

The frequency band 3400-4200 MHz is allocated on a primary basis to fixed and fixed-satellite service, of which typical systems are wireless access system, and FSS. Thousands of FSS earth stations are operating in the frequency band 3400-4200 MHz, especially in 3600-4200MHz frequency range.

According footnote CHN28 of [2], in the band 3400-3700 MHz, the quoted international footnotes on IMT application do not change the primary or secondary basis of existing services in the allocation table for mobile service. The study should be carried out on applying mode for the planned services, frequency arrangement, compatibility condition between services and coordination procedure in this band as soon as possible. Erenow, IMT applications are not put into practical operation.

5.5.1. Wireless access system

There are hundreds of wireless access center in use with high frequency occupancy in this band. For example, frequency occupancy of some wireless access station in Beijing is beyond 0.5.

According to document [13], in the four scenarios, including urban macro cell, suburban macro cell, outdoor microcell and indoor microcell, the separation distances between the IMT base station and microwave receiver are 50.4-92.0 km, 41.7-81.0 km, 13.4-45.0 km and 1.0-10.0 km in the co-frequency operation. The separation distances between the IMT UE and

wireless access receiver are 1.0-24.0 km, 1.0-31.0 km, 1.0-25.0 km and below 1.0 km. In adjacent frequency operation, the separation distances between the IMT and wireless access system could be 30 km depending on the frequency separation and antenna direction of microwave station.

5.5.2. Fixed satellite service

Dozens of FSS communication satellites are operating by Chinese operator in the frequency band 3400-4200 MHz. It is critical to protect the incumbent FSS stations from the harmful interference from IMT or avoid the restriction of development of FSS if this band is identified to IMT.

Document [14] specializes in the sharing and compatibility between IMT systems and FSS in the 3400-3600MHz frequency range in indoor environment. Table 9 shows the separation distance between LTE base station and FSS earth station in co-frequency channel when the maximum transmitting power of IMT base station is 24dBm/20MHz. Table 10 shows the separation distance between LTE UE and FSS earth station in co-frequency channel when the maximum transmitting power of IMT UE is 23 dBm.

Table 9 Separation distance between LTE base station and FSS earth station in co-frequency channel

off-axis angle between IMT and FSS station	separation distance
15 degree	520-680m
40 degree	440-540m
70 degree	440-540m

Table 10 Separation distance between LTE UE and FSS earth station in co-frequency channel

off-axis angle between IMT and FSS station	separation distance
15 degree	340-350m
40 degree	210-302m
70 degree	205-302m

The results also show the separation distance and additional isolation between the IMT UE and FSS earth station in adjacent frequency is relatively low in the different off-axis angles between IMT and FSS station.

For band 3400-3600 MHz, the amount of incumbent FSS stations is much smaller than those in band 3600-4200 MHz. And in general, criteria of spectrum sharing for indoor environment are less stringent than outdoor environment.

For band 3600-4200 MHz, existing usage of spectrum for FSS is extensive and the amount of FSS earth stations is large.

5.6. 4400-4500 MHz and 4800-4990 MHz

The frequency band 4400-4500 MHz is allocated on a primary basis to fixed service, of which typical system is microwave relay communication system.

The separation distance between IMT base station and microwave receiver is 46.1-72.0 km in the co-channel operation according to the document [15]. The separation distance between IMT base station and microwave receiver is in the order of tens kilometers in adjacent channel operation, with 45 dB of adjacent channel leakage ratio (ACLR). If an additional 30 dB of attenuation can be found through filtering and/or additional guard bands this distance may be reduced to 5 km.

For band 4400-4500 MHz and 4800-4990 MHz, hundreds of microwave relay stations are still in use. The requirement of spectrum sharing between IMT and microwave relay stations is relatively more flexible.

6. Proposals of optimization of spectrum usage

Information in this section can be used as a reference for discussion of the possible ways to increase the efficiency of spectrum usage. This will allow the valuable spectrum resource to be made available for new services such as IMT/mobile broadband, while maintaining existing spectrum uses.

6.1. Methods

Besides increasing spectral efficiency through technological improvement, increase in spectrum efficiency might also be achieved in some other ways according to international practice, such as:

Method 1: Band Segmentation

Repacking existing users from lightly used portions of a frequency band to more used area in order to free up parts of the bands. This method would be applicable to services which are occupying sparsely their allocated bands. It is proposed to amass the used frequencies together within the band, and the resulting continuous blank spectrum can then be replanned to accommodate new applications, with necessary guard-band when needed.

Method 2: Band clearance

In cases where bands are only used by a few stations/users, incumbent services can be migrated to other bands entirely. This would be applicable to bands with few stations deployed and with extremely low frequency occupancy, it is proposed to allocate new services or/and assign new applications.

Method 3: Geographical sharing

In cases where bands are only used in specific areas, one can envisage “geographic sharing”. For example if a band is only used in one city, then other geographic areas (that are distant enough not to cause undue interference) could be used for a new service such as IMT. It is proposed to share spectrum between new and incumbent services in different regions such as suburban and urban, or scenarios such as indoor and outdoor. The criteria of spectrum sharing are denoted in section 5.

Method 4: Using exclusive zones

In cases where bands are only used in a relatively few, known locations, exclusion zones might be defined. For example if a system is only used at major airports, then the new service might be limited to anywhere that is not within a given distance of these known locations.

Method 5: Using Dynamic Spectrum Access

In case where a temporary unused/unoccupied frequency band is implementing Cognitive Radio System (CRS), Dynamic Spectrum Access stands for the capability of operating on this band and moving to another frequency when an emission of the primary user of the band is occurring. However, it should be noted that this method is only theoretical at present, as there is currently no known case of implementation. It is therefore hard to predict how effective this method will be. Also, it would be the less preferred method as it creates uncertainty on the duration of spectrum resource availability, and therefore have a direct impact on the investments available to mobile network operation.

6.2. Applicable method for each band

The methods proposed to each band are listed in Table 11. "No Change" remains an option for all the bands listed in the table.

Table 11 Proposed methods to each band

Band	Method 1: Band Segmentation	Method 2: Band Clearance	Method 3: Geographical Sharing	Method 4: Exclusion zones	Method5: Dynamic Spectrum Access
470-694 MHz	√*				√
694-790 MHz	√	√			√
1300-1527 MHz	√*			√*	
2700-2900 MHz	√*	√*	√	√**	√
3300-3400 MHz	√		√	√	√
3400-3600 MHz		√*	√		
3600-4200 MHz	√*		√*		
4400-4500 MHz	√	√			
4800-4990 MHz	√	√			

*: Represent GSMA views, based on the monitoring results from section 4
**: Only proposed to be applied in local area

Following subsections are some supplement information on methods proposed by GSMA, based on the monitoring results from section 4.

6.2.1. 470-694 MHz

Band segmentation: After analogue to digital switchover, a single TV multiplexer of 8 MHz can contains up to 8 HD channels. 35 TV channels, as reported in previous section, can be repackaged into 5 multiplexers, occupying approximately 40 MHz bandwidth. Excluding the 566-606MHz, the band will still see approximately 140 MHz that can be segmented and repurposed to other usage.

6.2.2. 1300-1400 MHz

Band segmentation: It is noted that in some countries it has been proposed to segment the band at around 1350 MHz and move the radars to the band below rather than having the radars operational frequencies scattered all over the 1300-1400 MHz band and thus freeing up spectrum in the band above 1350 MHz useful for IMT systems. As there are only a dozen of radars involved, the "re-tuning" of the radar systems should be relatively straightforward.

Exclusion zones: As the registration database show only dozen of radar system in this band and have known location, exclusion zones can also be defined around those radars. The entire 1300-1400 MHz band could then be used for new service outside of these exclusion zones. The studies which included a frequency separation between the IMT and radar operations show that, under the assumptions used, operation of IMT is possible with a combination of frequency and physical separation. For IMT uplink, some studies have shown that sharing with radar would be feasible with a reasonable frequency separation (in the order of 10 MHz) and a small exclusion zone (1-2 km, or less if the spurious emissions from IMT UEs are lower than the generic standard).

6.2.3. 2700-2900 MHz

Band segmentation: It is also noted that in some countries it has been proposed to segment the band and move the radars to the higher end of the frequency band rather than having the radars operational frequencies scattered all over the band, and thus freeing up spectrum in the

lower end of the band useful for IMT systems. In this way only the non-co-channel interference characteristics need to be considered and these are a lot easier to mitigate as can be seen from the studies contained in document [9].

Monitoring results show only sparse usage in the lower part of the band (2707-2709 MHz, 2743-2745 MHz) and more sustained occupancy in 2850-2900 MHz. It should be possible to repackage all radars into the higher part of the band, and still have over 100 MHz of bandwidth and necessary guardband to be repurposed for new services.

Band clearance: Moving radars services to 2900-3100 MHz, which is also a band primarily allocated to radiolocation and radionavigation, would also be a possibility. If feasible, this will allow the band 2700-2900MHz to be fully replanned. However, the assessment of occupancy of 2900-3100 MHz is not within the scope of this report, and further study is required.

Exclusion zones: The studies which included a frequency separation between the IMT and radar operations show that, under the assumptions used, operation of IMT is possible with a combination of frequency and physical separation. For IMT uplink, some studies have shown that sharing with radar would be feasible with a reasonable frequency separation (in the order of 10 MHz) and a small exclusion zone (1-2 km, or less if the spurious emissions from IMT UEs are lower than the generic standard).

6.2.4. 3400-3600 MHz

Band clearance: The monitoring results show that FSS usage is not as extensive in this band as in higher part of the C-band, and the higher part of the C-band is occupying about 60-70% of their allocated frequencies. One possibility could be to move exiting FSS from 3.4-3.6GHz to 3.6-4.2GHz to optimize the utilization. And therefore clear the band for exclusive IMT usage for both indoor and outdoor.

6.2.5. 3600-4200 MHz

Band segmentation: The monitoring results show that FSS usage in the frequency band 3700-4200MHz is occupying about 60-70% of their allocated frequencies. It is noted that in CEPT countries it has been proposed to segment the band at around 3800 MHz and move the FS and FSS to the band above rather than having the operational frequencies scattered all over the 3600-4200 MHz band, and thus freeing up spectrum in the band below 3800 MHz useful for IMT systems.

Geographical sharing: According to document [16], the sharing criteria for 3.6-4.2 GHz is the same as 3.4-3.6 GHz. Therefore, it is proposed to consider geographical sharing for this band as for the lower part of C band. This could be indoor/outdoor sharing, or using part of the C-band for IMT in dense urban area and for satellite in rural area where there is more likely to be deployment of FSS stations.

6.2.6. Conclusion

Although the occupancy of the bands is a significant factor in the viability of these options, the feasibility of the above options will depend on a number of factors that are not addressed in this report, such as the costs of implementing any of these options. For the spectrum planning in the future, each administration should adopt the most proper option for itself, on the basis of comprehensive assessments of its practical spectrum usage situation.

7. Summary

This report contains the result of the spectrum occupancy measurement in China in the bands 470-566 MHz, 606-790 MHz, 1300-1527 MHz, 2700-2900 MHz, 3300-4200 MHz, 4400-4500 MHz, and 4800-4990 MHz. The major incumbent and planned radio system in these bands are identified and analyzed. The assessments of usage of spectrum are executed taking into account frequency band occupancy measurement, incumbent radio stations and compatibility sharing studies. 5 options to increase spectrum utilization are proposed: Band segmentation, Band clearance, Geographical sharing, Using exclusion zones and Using DSA, referring to Method 1, 2, 3, 4 and 5.

Comprehensive proposals of SRMC and GSMA are following: Method 1 is proposed to be employed in all bands excluding 3400-3600 MHz, Method 2 in band 698-790 MHz, 2700-2900 MHz, 3400-3600 MHz, 4400-4500 MHz and 4800-4990 MHz, Method 3 in band 2700-2900 MHz, 3300-3400 MHz, 3400-3600 MHz and 3600-4200 MHz, Method 4 in 1300-1527 MHz, 2700-2900 MHz and 3300-3400 MHz, Method 5 in band 470-698 MHz, 698-790 MHz, 2700-2900 MHz and 3300-3400 MHz, while “No Change” remains an option for all the bands.

These proposed methods should be considered as potential solutions in order to increase spectrum utilization based on assessment made within the scope of this report. However, the feasibility of these options will also depend on factors not addressed in this report, such as the costs of implementing any of these options. Administrations including China should carry out a full range of assessment on spectrum usage with a view to all instrumental factors, before they adopt the most appropriate measure.

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