Airspan

Wireless Fixed Access

System Description

Airspan Communications

Cambridge House • Oxford Road
Uxbridge • Middlesex • UB8 1UN • U.K.

Telephone: +44 (0) 1895 467 100
Fax: +44 (0) 1895 467 101

Email: marketing@airspan.com
Website: http://www.airspan.com

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Contents

1 Executive Summary

This document describes Airspan Communications Corporation (ACC)'s Wireless Fixed Access (WFA) systems. These systems meet the requirements of network operators who wish to offer copper-equivalent services via radio.

Airspan's systems were created to:

- Support a complete range of telecommunication services including telephony, Group 3 and Group 4 facsimile, payphone, data modems, high-speed leased line data, Internet Access and basic rate ISDN.
- Be economical to deploy in urban, suburban and rural areas.
- Have capacity that can be easily expanded as the customer base grows.
- Minimise initial capital outlay.
- Operate in a Point-to-Multipoint system configuration.
- Conform to the ETSI standards EN 301 055 and 301 124 for CDMA Point-to-Multipoint systems in the 1-3GHz and 3-11GHz bands.

Airspan's systems are best described as a "flexible access tool" for network operators to provide a variety of services to their end-user customers. Significantly, they are able to provide services that are the same quality and performance as wireline services, by supporting a transparent connection to the operator's network. The combination of voice coding at either 64kbit/s PCM or 32kbit/s ADPCM, Bit Error Rates (BER) of better than 1×10^{-6} and low delay (typically <10ms), ensure that advanced telephony services, including G3 facsimile and high speed data modems (up to 56kbit/s) for Internet applications are fully supported. They are also the only fixed WLL systems to fully support basic rate ISDN service in the 2B + D channel format.

The latest enhancement to the AS4000 family is PacketDrive technology. This enables high speed data applications to be delivered to customers, so that users have access to an 'always on' internet connection delivering up to 512kbit/s, together with one or two regular POTS lines for voice communications.

Airspan's systems support numerous applications within both existing and new telecommunications networks, and has been deployed in both developed and developing country environments. For example:

- International CLEC operators who want to differentiate their services from incumbents by offering hybrid voice and high speed data.

- In developing countries to reduce the waiting list for telephony services, in residential, business and payphone applications. This enables rapid deployment of a low cost / high value telephony infrastructure that typically exceeds the quality and performance of existing copper access networks.

- In developed countries as a "copper alternative", to modernise the access networks, reduce operating costs and thus reduce the cost of universal service provision.

- In both developed and developing countries to provide a "local loop bypass", allowing a new operator to provide wireless based services at a quality normally only available with wireline networks. Additionally the system is cost effective and quick to deploy compared with traditional copper access networks.

- In leased line and ISDN data-only networks for operators with data-only licenses.

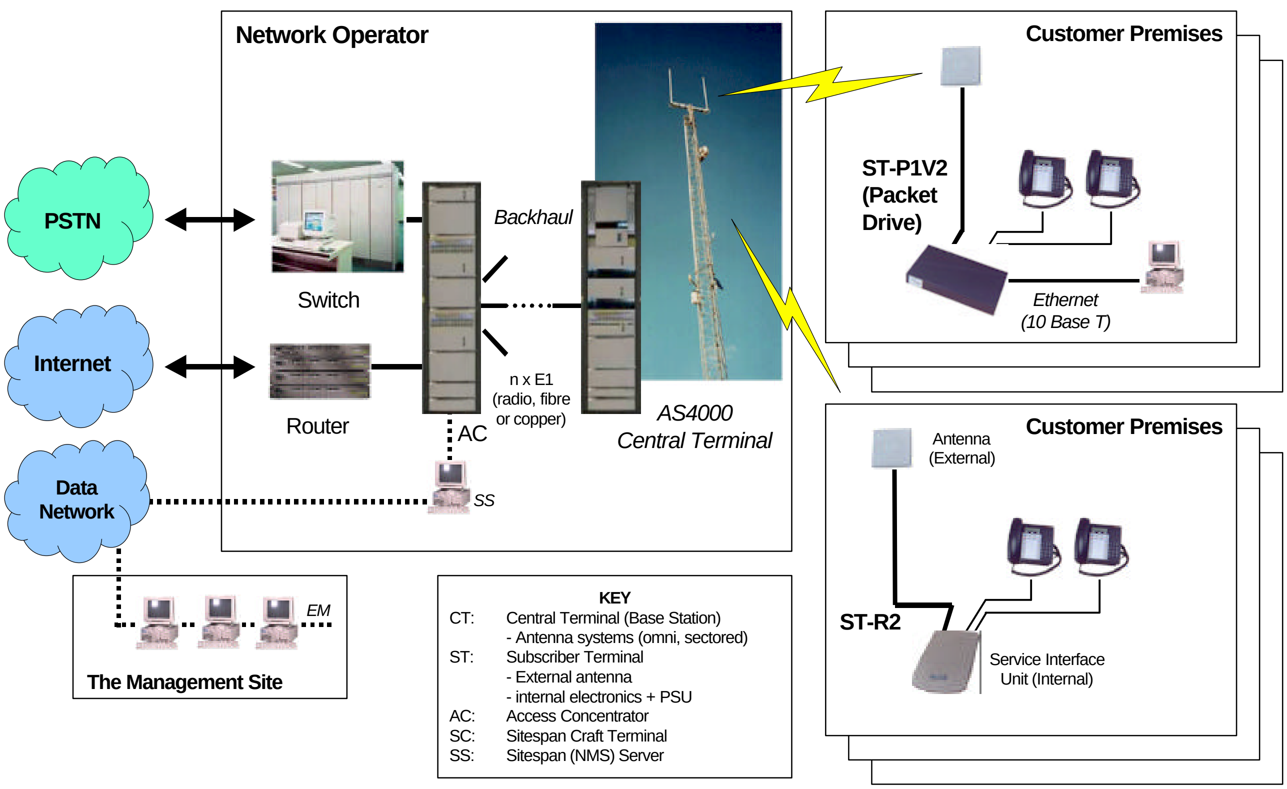
- In private networks to provide a range of telephony and leased line data services supported by transmission rates of N x 64kbit/s (N = 1 to 6).

2 Wireless Fixed Access

2.1 System Overview

Airspan's Wireless Fixed Access (WFA) systems are digital point to multipoint radio access systems providing wireless access for fixed end-users to a telecommunication operator's network.

AS4000 is specifically designed for Wireless Fixed Access applications. AS4000 delivers a wide range of services, including telephony, voice-band facsimile/data, basic rate ISDN, leased line data, and packet-oriented interfaces for always-on internet connections. Distances up to 25km can be covered. AS4000 is therefore an attractive alternative to traditional copper "local loops" for the delivery of these services to end-users. Furthermore it is a better services platform than pure voice WLL systems or packet-only configurations.



General System Architecture

AS4000 uses point to multipoint microwave radio links between the individual end-user's premises and the network operator's "local point of presence" as an alternative to the copper pair "local loop". The "local point of presence" would typically be the local exchange premises. If greater flexibility or range is required, the Central Terminal (cell site) equipment can be remotely located in a suitable building or an environmentally protected wayside cabinet, and connected to the local exchange via radio, cable or fibre digital transmission links.

Both Fixed Assigned (FA) and Demand Assigned (DA) modes of bandwidth allocation between the Central Terminal and Subscriber Terminals are supported.

The range of services supported includes:

- Analogue telephony (POTS).

- Always-on TCP/IP connections.

- Voice-band Group 3 facsimile and data up to 33.6kbit/s (extending to 56kbit/s where there are digital interfaces between Airspan and the switch network).

- Payphones, including pulse metering.

- CLASS services.

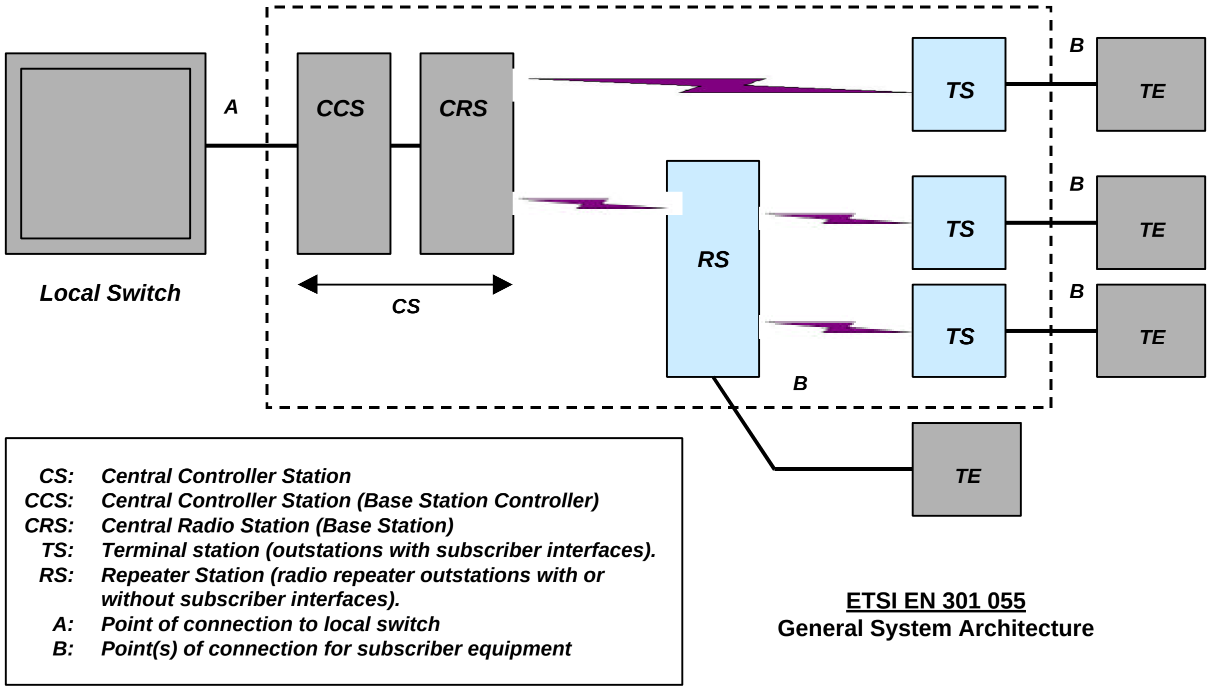
- 64kbit/s and n x 64kbit/s leased line data services.

- Basic rate ISDN (2B + D).

A portfolio of Subscriber Terminals (ST) are available supporting one or more lines at each end-user location.

2.2 Conformance to Standards

Airspan's WFA system architecture is in accordance with the ETSI standards EN 301 055 and 301 124 for Direct Sequence Code Division Multiple Access (DS – CDMA) Point-to Multipoint digital radio systems as shown below:



ETSI EN 301 055
General System Architecture

The ETSI standard permits an operator to use systems from different vendors. The standard addresses:

- Interoperability on Radio interface: Spectrum Masks, Spurious Emissions, Receiver Specs, Co and Adjacent Channel Interference Performance are defined. Reference is made to relevant ITU-R and CEPT standards.

- Host Network Interconnection is covered by references to relevant ETSI V5.x standards and TMN standards.

- Subscriber Services and Interconnection is covered by reference to relevant ITU-T standards.

2.3 System Interfaces

Interfaces between the various elements of Airspan's systems are as follows:

2.3.1 The Central Office / Exchange Interface (Voice & ISDN services)

The interface between the WFA systems and the switch is N x 2Mbit/s G703 / G704 (1 per radio carrier typically 4 per CT).

In the **Fixed Assigned** mode the following signalling protocols are supported:

- Channel Associated Signalling (CAS). Variants are available to interface with switches from Ericsson (AXE), Nortel (DMS-100) and Siemens (EWSD). Variants can be made available to interface with other manufacturers digital switches that have 2Mbit/s subscriber ports. This protocol also supports 2 wire analogue interfaces via channel banks, such as the LS-120.

- Common Channel Signalling (CCS). UK DASS2 is available to interface with GPT (System X) and Ericsson (AXE) switches. DSS1 signalling to support Euro-ISDN is available to interface with Alcatel (S12) and Ericsson (AXE) switches. In addition V5.1 is supported.

In the **Demand Assigned** mode the Access Concentrator (AC) provides the primary network interface which is N x 2Mbit/s, as per ITU recommendation G.703, short haul 6dB, G.704 and ETSI ETS 300-166.

All signalling is digital using either Channel Associated Signalling (CAS) or Common Channel Signalling (CCS) protocols. The DA system interfaces to digital switching systems that have 2Mbit/s subscriber ports.

Support for 2-wire VF interfacing is via external channel bank equipment.

- Channel Associated Signalling. Support for timeslot 16 ABCD bit CAS is provided. Airspan's management systems allow for flexible configuration of the protocol, to interface with switches from various manufacturers.

- Common Channel Signalling. V5.1 and V5.2 are supported by the DA system. Proprietary protocols such as DASS2 and DSS1 may be supported through appropriate software loads.

- The V5.1 network interface as specified in ETS 300-324-1 is used for the presentation of traffic at a non-concentrated interface. The V5.1 interface supports POTS, ISDN and data services.

- The V5.2 network interface as specified in ETS 300-347-1 is used for the presentation of traffic at a concentrated interface. The V5.2 interface supports both POTS and basic rate ISDN services. The AC supports V5.2 groups of up to 16 E1 links.

- The AC supports dedicated data services using 64kbit/s timeslots. Cross-connect at the 64 kbit/s level from any input / output port is configurable via the management systems.

- GR303 and T1 interfaces are also supported

2.3.2 The Operator Interfaces (TCP/IP networks)

- For operators deploying AS4000 with PacketDrive features, the network-side interconnect consist of 100bT connections on standard ethernet cable.
- This can be flexibly combined with voice and data interfaces

2.3.3 The Operator Interfaces (Leased line data networks)

- Standard G.703 2Mbit/s interfaces are presented to the network.
- The allocation of timeslots on the E1 connections can be managed and groomed via the cross-connect functions built into the AC.
- These interfaces may form part of a combined V5.x presentation, or may be presented on separate interfaces as desired. They can also be combined flexibly with PacketDrive network interfaces.

2.3.4 The Radio (Cell) Site

The network-side (backhaul) interface to the Central Terminal is up to 4 x 2Mbit/s G703 / G704 interfaces. This is connected to the Access Concentrator or directly to the Switch. In the DA system this backhaul supports concentrated and compressed traffic.

2.3.5 The Subscriber Site

This is normally country specific in line with the national customer terminal interface specification(s), and versions are available that meet most requirements.

2.4 Equipment Overview

Airspan’s systems consist of four main network elements:

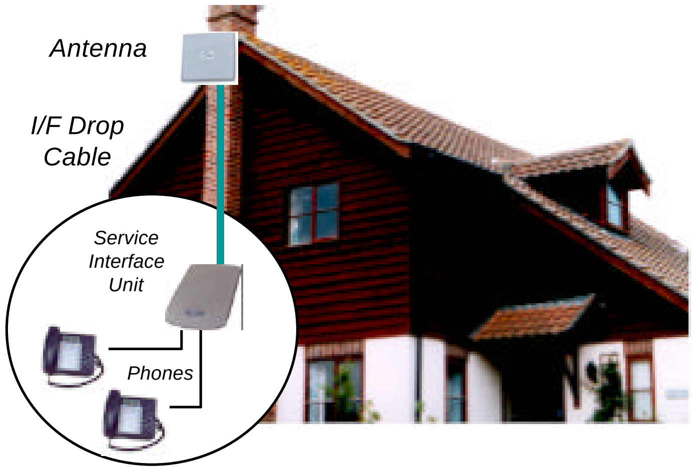
- The Subscriber Terminal (ST) which is located at the end-user’s premises.

- The Central Terminal (CT) which is located at the radio site or at the switch site.

- The Access Concentrator (AC) which is normally located at the switch site. This is only required for the Demand Assigned version of the system.

- The Management system normally consists of AS8100 clients, located at an Operator’s network management centre, with AS8100 servers distributed throughout the network.

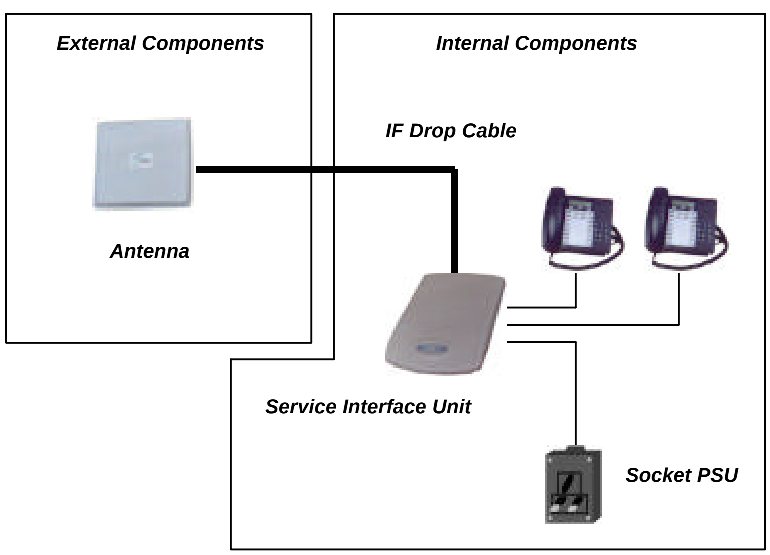
2.4.1 Subscriber Terminals



Subscriber Terminal (ST)
(example shows ST-R2)

2.4.1.1 The Subscriber Terminal

The architecture of the ST comprises two principal units. The outdoor unit contains a directional antenna and RF front end. This is small, light and easy to install. The remainder of the electronics is contained in a Service Interface Unit, normally located inside a customer's premises. This is connected to the outdoor unit by a coax drop cable. A small 12VDC mains PSU completes the installation.



There is a range of STs available, each supporting different services and numbers of lines.

- The **ST-R1** and **ST-S1** supports one 32kbit/s or 64kbit/s analogue telephony line at the end-users premises. Provisioning is by the management system.

- The **ST-R2** and **ST-S2** supports two 32kbit/s or 64kbit/s analogue telephony lines at the end-users premises. Provisioning is by the management system.
- The **ST-P1V2** supports an always-on 10bT Ethernet RJ11 interface for connection to the internet, plus two 32kbit/s or 64kbit/s analogue telephony lines at the end-users premises. Provisioning is by the management system.

- The **ST-B1** supports a basic rate ISDN, 2B+D (2 x 64kbit/s + 16kbit/s) "S" interface, and normally operates in Fixed Assigned mode.

- The **ST-L128** supports 64kb/s or 128 kb/s clear channel data services via an RS530 interface.

- A number of **multi-line STs** are available, ranging from the **ST-N4** 4-line unit to the **ST-M16** for up to 16 analogue POTS lines.

STs are powered from the AC mains supply, with or without backup batteries.

2.4.2 The Central Terminal

The Central Terminal (CT) is the Base Station. This is deployed in omni or sectored cell configurations supporting variable numbers of STs per cell. The CT is a multi-service platform hosting single and dual line telephony, multi-line telephony, digital data leased lines and ISDN basic rate interfaces. The CT can operate in two modes, depending on the type of service and traffic levels supported. Fixed Assignment is used when STs must have a dedicated radio link. Demand Assignment is utilised when STs can share the available radio resources, and sustain an “engineered” grade of service.

The CT provides the traffic interface to the network switching, either directly for Fixed Assigned systems or via the Access Concentrator for Demand Assigned systems. The CT also provides an interface to the management systems.

2.4.3 The Access Concentrator

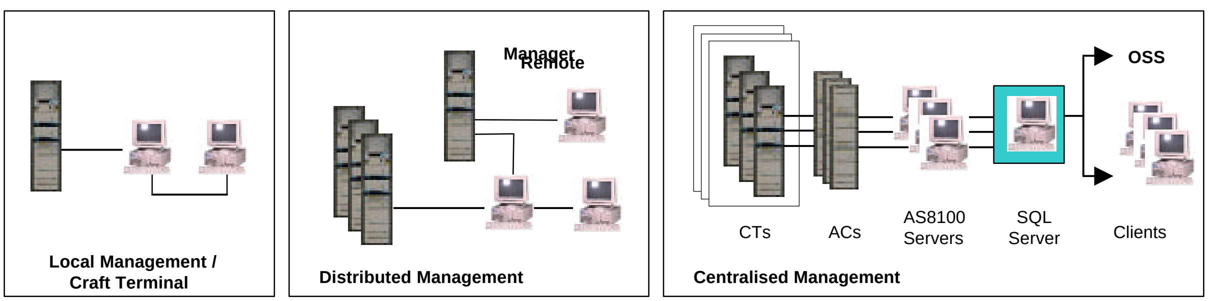
The Access Concentrator (AC) is required when the system is operating in “Demand Assigned” mode to de-multiplex the traffic concentrated on the air-interface for presentation to the network switching equipment. Also in system versions using 32kbit/s compression the decompression to 64kbit/s is performed within the AC.

2.5 The Management Systems

Airspan’s Management systems monitor, test and configure the WFA systems:

- STMON: a standalone “CRAFT terminal” for installation, operation and maintenance of the subscriber terminals.

- AS8100 Sitespan Manager: a scaleable, distributed PC based management system, that can be used for commissioning or full-scale management, including integration with an operator’s OSS system.



For Demand Assigned systems, interfaces for connection to the management system are supported as follows:

- AC: 2 x RS232, 9600 baud
- AC: 2 x Ethernet, optional
- CT modem shelf: 2 x RS232, 9600 baud
- CT modem shelf: 1 x Ethernet, optional
- CT modem shelf: embedded within E1, backhauled to the AC.

Management communications routing is flexible. The AC supports consolidation of management communications from dependent CT equipments to provide a single management interface.

3 System Air Interface

3.1 CDMA Technology

Airspan’s systems use a radio air-interface, specifically designed for Wireless Fixed Access to provide high quality, and low delay bearers for telephony, data and ISDN services

The systems use Direct Sequence Spread Spectrum Code Division Multiple Access (DS-CDMA) on the air-interface between the CT and STs, allowing multiple radio links to share the same RF channel. A set of specialised codes is used which are shared between the ST and its corresponding modem in the CT.

There are two stages to the CDMA modulation / demodulation process. Firstly direct sequence spreading is performed on each individual radio link by a pseudo-random noise (PN) code. Then multiple access, where multiple links share the same RF channel, is achieved by using a set of orthogonal Rademacher - Walsh (RW) codes. The PN and RW codes are combined into a unique and shared composite code used to modulate and demodulate each radio link.

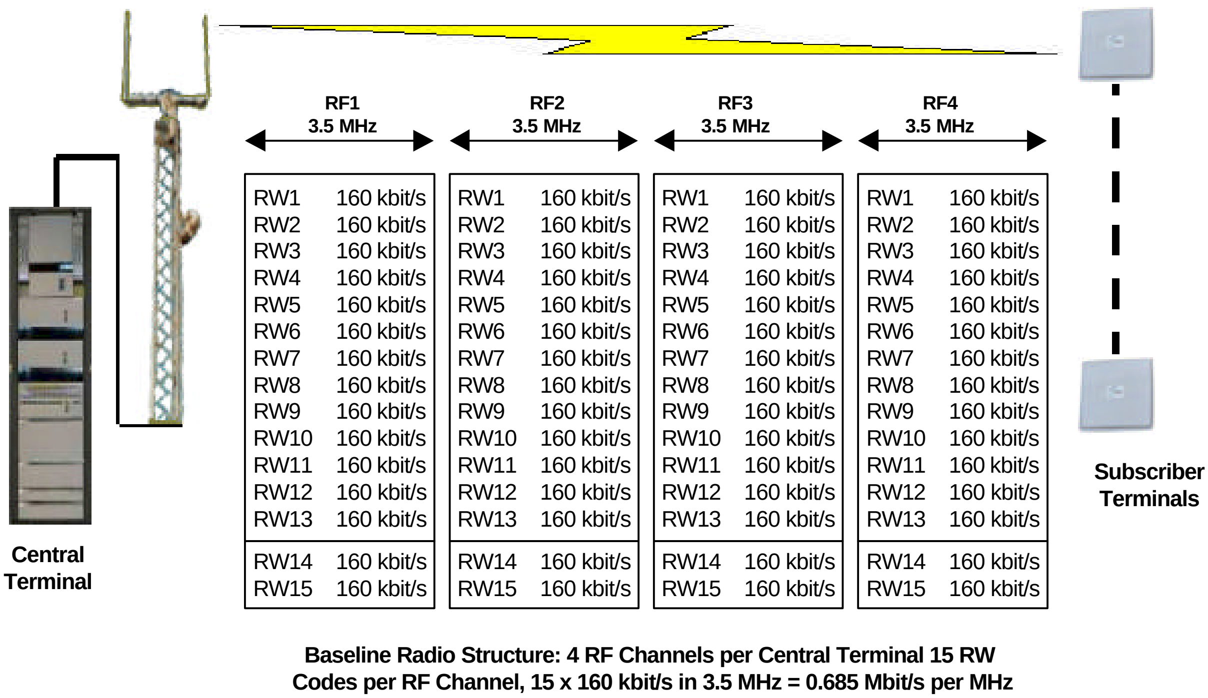
Airspan’s systems implement a version of CDMA optimised for fixed access. This is significantly different from other commercial CDMA implementations, such as IS-95, which are optimised for mobile cellular and PCS applications.

The following table demonstrates the difference in implementation and performance between the two systems:

	Cellular (IS-95)	**Fixed (Airspan)**
Application	PCS	Wireless Fixed Access
Frequency of operation	8-900,1800-1900 MHz	1.3-3.6GHz
RF Channels (BW)	1.23MHz	3.5MHz
Channel Bit Rate	9.6kbit/s	To 144kbit/s
Processing Gain	21 dB	12-24dB
Processing Delay	>20ms	<1ms
FEC	1/3	1/2
Code Structure	Quasi Orthogonal	Orthogonal
Receiver Type	Rake	Coherent
RF Synchronised	No	Yes
Synchronised Base Stations Required	Yes	No

3.2 Air-Interface Structure

The system's Radio Interface structure supports both "Fixed" and "Demand" assigned modes for allocation of radio capacity to users. The air-interface protocol and structure is compatible between both assignment types. The basic structure of the interface is shown below:



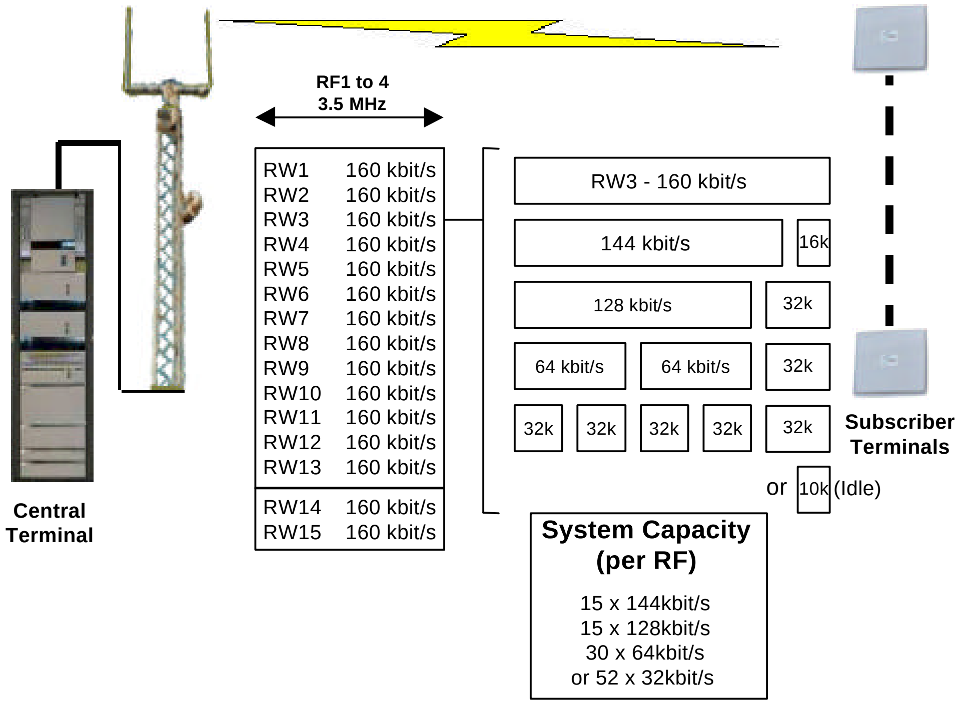
RF1		RF2		RF3		RF4	
RW1	160 kbit/s	RW1	160 kbit/s	RW1	160 kbit/s	RW1	160 kbit/s
RW2	160 kbit/s	RW2	160 kbit/s	RW2	160 kbit/s	RW2	160 kbit/s
RW3	160 kbit/s	RW3	160 kbit/s	RW3	160 kbit/s	RW3	160 kbit/s
RW4	160 kbit/s	RW4	160 kbit/s	RW4	160 kbit/s	RW4	160 kbit/s
RW5	160 kbit/s	RW5	160 kbit/s	RW5	160 kbit/s	RW5	160 kbit/s
RW6	160 kbit/s	RW6	160 kbit/s	RW6	160 kbit/s	RW6	160 kbit/s
RW7	160 kbit/s	RW7	160 kbit/s	RW7	160 kbit/s	RW7	160 kbit/s
RW8	160 kbit/s	RW8	160 kbit/s	RW8	160 kbit/s	RW8	160 kbit/s
RW9	160 kbit/s	RW9	160 kbit/s	RW9	160 kbit/s	RW9	160 kbit/s
RW10	160 kbit/s	RW10	160 kbit/s	RW10	160 kbit/s	RW10	160 kbit/s
RW11	160 kbit/s	RW11	160 kbit/s	RW11	160 kbit/s	RW11	160 kbit/s
RW12	160 kbit/s	RW12	160 kbit/s	RW12	160 kbit/s	RW12	160 kbit/s
RW13	160 kbit/s	RW13	160 kbit/s	RW13	160 kbit/s	RW13	160 kbit/s
RW14	160 kbit/s	RW14	160 kbit/s	RW14	160 kbit/s	RW14	160 kbit/s
RW15	160 kbit/s	RW15	160 kbit/s	RW15	160 kbit/s	RW15	160 kbit/s

System Air-Interface Structure

Depending on the service applications and traffic levels to be supported, this structure is used in two different ways:

3.2.1 Fixed Assignment

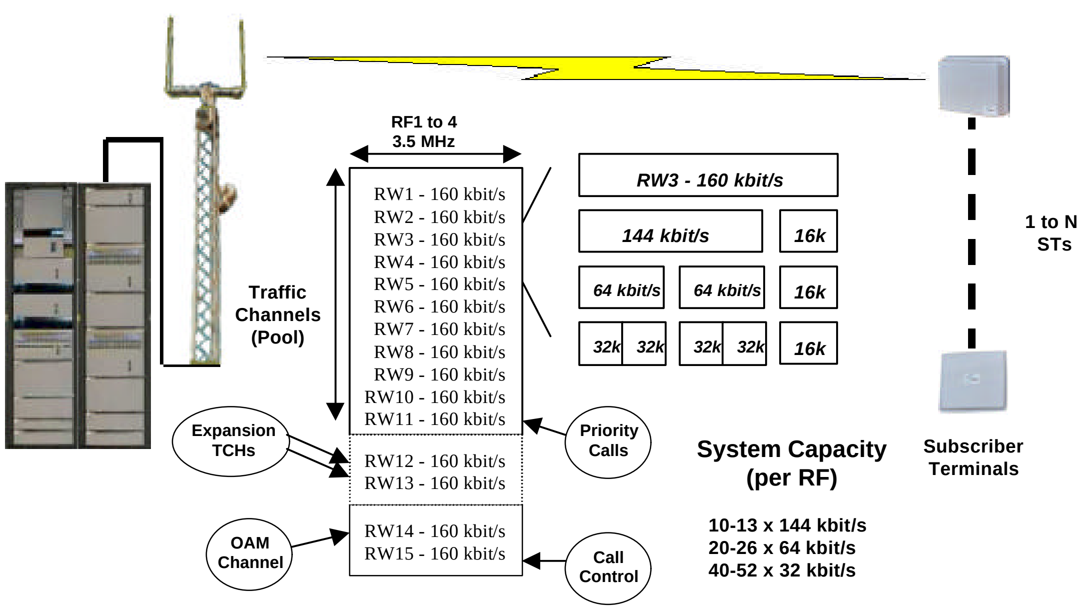
The "Fixed Assigned" mode makes a permanent allocation of a radio link, operating within a RF channel to a subscriber terminal. Each link provides 32, 64, 128 or 144kbit/s of user payload together with OAM. In telephony applications where the subscriber is "on-hook" the ST will use "rate switching", reducing the link bandwidth to 10kbit/s, and hence decreasing the level of Access Noise on the RF channel.



Fixed Assigned Air-Interface Structure

3.2.2 Demand Assignment

The “Demand Assigned” Radio interface makes a temporary call by call assignment of channels, to Subscriber Terminals in residential telephony applications, where the per line traffic allows the provision of Graded Service. The radio interface differs in that links are allocated as either Traffic, or Control channels.



Demand Assigned Air-Interface Structure

Within each RF Channel a pool of traffic channels (TCH) supports a mix of 32, 64, and 144kbit/s services. Pool management is dynamic so that channels may be made available as 32, 64, and 144kbit/s on demand. The size of the traffic pool is automatically and dynamically sized based on radio interface performance and the grade of service requirements thus controlling the level of Access Noise. The pool can be extended if the interference level permits, or reduced if access noise is too great. The DA access protocol can also support one or more priority channels which allow guaranteed access for emergency calls. The channels allocated to traffic are pooled and configured as either 10-13 x 144kbit/s, 20-26 x 64kbit/s, or 40-52 x 32kbit/s. Two links are reserved for OAM and Call Control.

Each link operates using a master RW code to provide a 160kbit/s channel. These links are then sub-divided using 2nd level RW codes that allow the construction of 2 x 80kbit/s or 4 x 40kbit/s smaller granularity links, while maintaining the same Spectral Density. Hence TCHs are composed of 160kbit/s, 80kbit/s or 40 kbit/s links.

STs maintain communication with CT via the Call Control link, using an “Ethernet” like protocol. All STs are continually polled, and receive regular downloads of available TCHs and their channelisation (i.e. 144kbit/s, 64kbit/s or 32kbit/s).

STs track available TCHs to permit “fast acquisition”. When a user’s line goes “off-hook”, STs request allocation of a TCH from the available pool. The CT instructs STs to “seize” a particular TCH, if access noise permits. Traffic engineering is via the management system, which allows the following parameters to be programmed:

- Minimum / maximum number of traffic channels
- Number of access channels
- Demand access protocol type
- BER grade of service threshold
- Call blocking threshold
- Number of priority channels

3.3 Frequency Ranges Supported

Airspan’s systems operate in various frequency ranges within the PCS, ITU-R and ETSI 2GHz and 3GHz frequency ranges. The specific channel plans available (see Appendix B) operate in frequency bands at:

- 1.8 - 1.9GHz, for deployments in the PS A-Band with 80MHz duplex spacing
- 2.0- 2.3GHz, in accordance with CEPT/ERC/Rec. 13-01E, Annex C, with 175MHz duplex spacing
- 2.3 - 2.5GHz, in accordance with ITU-R 746, with 94MHz duplex spacing
- 3.6GHz, in accordance with CEPT/ERC/Rec. 14-03E (Turku 1996), with 100MHz duplex spacing

The systems operate in licensed spectrum, normally co-ordinated with other users by the licensing authority. Coexistence with other systems is in-line with ETS 301 055 and 301 124.

3.4 Radio Link Budget

Airspan's systems operate in rural, suburban and urban areas in either omni-cell or sectored cell configurations.

System performance is governed by the link loss relative to available Link Budget. Therefore for shorter links Line Of Sight (LOS) propagation is not necessarily required and Near Line Of Sight (NLOS) links operate satisfactorily.

The system range is dependent on the location and ground height of the CT sites and tower heights, relative to the ST locations and the environment in which the system is operating. Ref. 5.5.

Frequency:	**1.8-1.9**	**2.0-2.5**	**3.4-3.6**	GHz
UPLINK				
ST PA output power	+21.0	+18.0	+18.0	dBm
ST Cable and connector loss	-0.5	-0.5	-0.5	dB
ST antenna gain	10.5	11.5	13.5	dBi
ST effective radiated power (a), per link	31.0	29.0	31.0	dBm
CT antenna gain (b), Omni	10.5 †	10.5 †	10.5 †	dBi
CT Cable and connector loss (d), 50m	-3.5	-3.5	-5.0	dB
CT Receiver sensitivity for $\mathbf{10^{-7}}$ BER (e)	-98.0	-98.0	-98.0	dBm
Maximum path loss (j=a+b-d-e)	136.0	134.0	134.5	dB
Fade Margin for **99%** Link availability	4-10	4-10	4-10	dB
DOWNLINK				
CT PA output power, per link	21.0	+21.0	+18.0	dBm
CT Cable and connector loss, 50m length	-3.5	-3.5	-5.0	dB
CT antenna gain**,** Omni	10.5 †	10.5 †	10.5 †	dBi
CT effective radiated power, Per Link (a)	28.0	28.0	23.5	dBm
ST antenna gain (b)	10.5	11.5	13.5	dBi
ST Cable and connector loss (d)	-0.5	0.5	0.5	dB
ST Receiver sensitivity for $\mathbf{10^{-7}}$ BER (e)	-98.0	-98.0	-98.0	dBm
Maximum path loss (j=a+b+d-e)	136.0	137.0	134.5	dB
Fade margin for **99%** Link availability	4-10	4-10	4-10	dB

† Note: the CT antenna gain increases to 17dB for a 65° directional antenna

3.5 Cell Planning Criteria

Airspan's portfolio includes AS8100 AirPlan, an RF coverage prediction tool which is used to optimise CT site locations for area coverage. See section 9.

The system range depends on the propagation conditions, which are a function of the environment in which the system is deployed:

- In a Rural environment 2nd order propagation is assured, giving a range of typically 8 - 15km. Line density is typically 1 - 10 per km^2.
- In a Sub-urban environment 3rd order propagation is assured, giving a range of typically 5 - 8km. Line density is typically 10 - 100 per km^2.
- In an Urban environment 4th order propagation is assured, giving a range of typically 3 - 5km. Line density is typically 100 - 500 per km^2.

Typical planning parameters used are as follows:

Propagation prediction model	See comments below
Link Availability %	99%
Required C/I for frequency allocation	8.0dB
Frequency reuse for maximum load	N = 3
Minimum RF spacing, one sector	Adjacent plus One - 7MHz
Minimum RF spacing, one site	Adjacent - 3.5MHz
Guard band requirements	Per CEPT / ITU channel plan

The system adheres to the typical microwave propagation model, i.e. for rural areas:
Path Loss = 32.44 + 20Log D + 20Log F, assuming 0.6 FZC is achieved.

Testing has shown that the impact of an obstruction on the system closely mirrors theoretical work on propagation modelling by ITU-R (CCIR) for microwave point-to-point systems in the 2 & 4GHz bands.

The model that best describes the effect of grazing on the radio path is a derivative from a "multiple knife edge diffraction" model. The basic work on this model was done by Bullington in 1947, and was finally refined by Deygout in 1966, when it appeared in CCIR Report 715. This methodology is an extension of a single knife edge diffraction calculation.

In 1971 ASIS showed how this approach could be extended using "multiple rounded obstacles", in place of multiple knife edges. This is the basis for the Airspan's propagation model. The technique employed to calculate these type of losses is defined in CCIR Rec. 526-2, and involves representing the path as a series of "cascaded cylinders".

4 Services Supported

4.1 Wireline equivalent POTS services

The following services are supported:

- **Telephony**, including the in-band support for G3 facsimile and data modems operating at up to 56kbit/s.

- **CLASS** services as supported by the Local Switch.

4.2 Wireline equivalent Leased line data services

- **Leased Line** data services supporting currently 1 x 128kbit/s or 2 x 64kbit/s per ST. Future enhancement to 8 x 64kbit/s are planned.

4.3 Wireline equivalent ISDN services

- **Basic Rate ISDN**. All ISDN implementations fully support:

  ETS 300 011 / 012
  ETS 300 125 - Basic Call Layer 2 Data Link Layer I.440 & I.441 - Q.921
  ETS 300 102 - Basic Call Layer 3 (Q.931)

  Interfaces are generally defined by the ITU-T (CCITT) recommendations: I.420 (for Basic Rate) and I.421 for Primary Rate.

  Specification for Bearer Services is based on ITU-T recommendations I.230 and I.231.

ETS 300 108	Circuit Mode Bearer Service 64kbit/s unrestricted 8kHz structured
ETS 300 110	Circuit Mode Bearer Service 64kbit/s 8kHz structured for 3.1kHz audio

  Specifications for Basic Teleservices are:

I.240	Definition of Teleservices (Blue Book)
I.241	Teleservices supported by an ISDN. Telephony Part 1, Telefax 4 Part 3, Mixed Mode Part 4

ETS 300 111 Circuit Mode Teleservice Telephony 3.1kHz
ETS 300 120 Circuit Mode Telefax Group 4
ETS 300 263 Telephony 7 kHz
ETS 300 264 Video Telephony

The systems also support the following ISDN Supplementary Services:

ETS 300 092 Calling Line Identification Presentation (CLIP)
ETS 300 093 Calling Line Identification Restriction (CLIR)
ETS 300 064 Direct Dialling In (DDI)
ETS 300 052 Multiple Subscriber Number (MSN)
ETS 300 055 Terminal Portability (TP)
ETS 300 061 Sub Addressing (SUB)
ETS 300 027 Call Forwarding Unconditional (CFU)
ETS 300 058 Call Waiting (CW)
ETS 300 141 Call Hold (HOLD)
ETS 300 138 Closed User Group (CUG)
ETS 300 138 Advice of Charge at end of Call (AOC-E)

Fixed Assigned Radio Interfaces are fully service transparent:

- Full support for D-channel Services, including D-Channel Packet Access
- Support for ISDN services is dependent on the network interface passing the services transparently. Euro-ISDN and V5.x network interfaces provide fully transparent connections.

D-Channel Packet Access Specifications supported include:

ETS 300 007 Support of packet-mode terminal equipment by an ISDN
ETS 300 048 ISDN Packet Mode Bearer Services (PMBS) ISDN Virtual Call (VC) and Permanent Virtual Call (PVC)
ETS 300 049 ISDN Packet Mode Bearer Services (PMBS) ISDN Virtual Call (VC) and Permanent Virtual Call (PVC)
ETS 300 099 Specification of the Packet Handler Access Point Interface (PHI)

In addition the following D-channel based Supplementary Services are supported.

ETS 300 286 User to User Signalling (UUS)

4.4 Data Services Support

- A range of STs are available (R,S,N,M-series STs) that provide full support for **data services over analogue POTS** lines:

  - Data rates: Up to 56kbit/s in the voice band using the 64kbit/s codec, and 9.6kbit/s using the 32kbit/s ADPCM codec.
  - Bit error rates: Typically better than 1 x 10-6.
  - Transmission delays: One way system delays are below 10ms, having a minimal impact on data applications.
- A range of STs are available (B-series STs) that provide full support for data services over **ISDN** lines
- A range of STs are available (L-series STs) that provide full support for **Leased line** Data services
- A range of STs are available (P-series STs) that provide full support for **Packet data services** – see below

4.5 Access to the Internet

The following options are currently supported by the system:

- Use of in-band data modem on a circuit switched basis
- Use of ISDN on a circuit switched basis
- Use of leased lines on a dedicated basis

4.6 Packet Access capabilities with Airspan's PacketDrive technology

PacketDrive technology is a seamless extension of Airspan’s AS4000 system. With PacketDrive enhancements, service providers can deploy complete, wireless Internet access services in addition to their circuit-based services

PacketDrive terminals can be added incrementally to an AS4000-based network by employing Airspan’s existing CDMA air interface, with no changes at the Central Terminal base-station. This innovation thereby permits smooth network evolution for existing and new Airspan-based network operators.

PacketDrive permits users to enjoy high speed Internet access, at up 512 kb/s download speeds, together with complementary voice services. The PacketDrive terminal provides an Ethernet port for connection to a user's computer and up to 2 voice ports.

Sophisticated Quality of Service measures are provided by the AS8100 PacketDrive enhanced management system, which allows bandwidth to be carefully controlled and optimally allocated. Detailed service statistics are available for tariffing purposes.

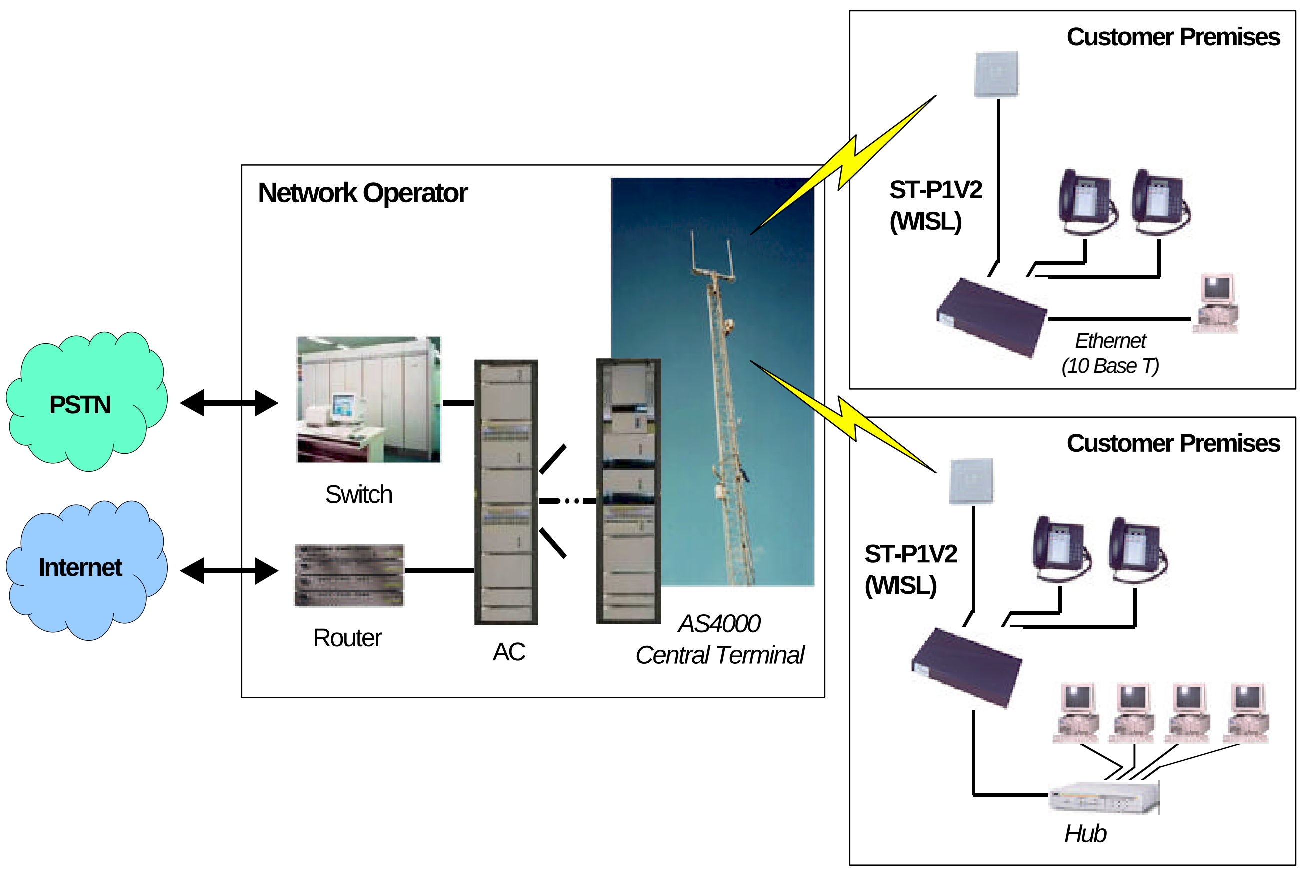
- Residential Internet access is mostly asymmetric, with downstream traffic typically 10 times upstream rate. The system has greater capacity on the CDMA downlink than on CDMA uplink.

- The STs operate at up to 512kbit/s. STs can receive data on multiple RW links, making the potential bandwidth of any digital service up to 512kbit/s downstream and up to 128kbit/s upstream.

- In this application the system is "end-to-end digital" - removing analogue A/D and offering improved performance compared with copper/voice band modem solutions.

- The system has error protection facilities that can ensure high quality data delivery.

- The system has built-in HDLC and TCP/IP facilities that enable the system to support packet data access.



Wireless Internet Access

4.7 Speech Coding

The system is based on either 64kbit/s PCM, to support full wireline equivalent services or 32kbit/s ADPCM for those applications where higher line density and quasi-wireline services are required.

4.8 System Security

ST authentication is carried out on a per call basis. Authentication uses encryption techniques to prevent an authentication response from being decoded and mimicked. An authentication request is issued by the CT equipment, which transmits a random code to the ST. The ST response is formed by non-linearly combining the random code with a known key. The key used for authentication comprises a static portion based on an unalterable electronic serial number (ESN) and a dynamic portion, which is updated following each authentication. Full authentication is delayed until the time critical phase of call set-up has been completed.

Authentication failure causes an alarm to be generated. Service blocking on authentication failure is configurable via the management system.

The ST serial number contains a portion which is unique and unalterable, i.e. not held in a memory that could be altered or duplicated. This portion of the serial number is 32-bits in size.

5 System Capacity (Demand Assigned Mode)

5.1 Radio (RF) Channel Capacity

The capacity calculations shown below are for a single (3.5+3.5MHz) RF channel operating in a single Omni-cell or cell sector.

5.1.1 Number of Traffic Channels (TCHs) for isolated cell

	144kbit/s	64kbit/s	32kbit/s
Omni-directional cell	13	26	52
Three sector cell	39	78	156

5.1.2 Number of TCHs for contiguous cell pattern

	144kbit/s	64kbit/s	32kbit/s
Omni-directional cell	10	20	40
Three sector cell	30	60	120

5.1.3 Dynamic frequency allocations

Where multiple RF channels are supported from a single CT equipment, then STs will be offered service from all RF channels to support:

- Fault tolerance: should a CT modem shelf fail, an ST may automatically switch to an alternative frequency for service for the duration of outage

- Increased trunking efficiency of the air-interface

- Traffic load balancing: An ST may be moved through manual intervention using the management system in order to balance traffic load across multiple CTs

- Frequency diversity: An ST may be moved through manual intervention using the management system in order to improve radio link performance

At provisioning, an ST will be allocated a 'home' CT shelf (RF Channel) through which all usual management communications may be directed. The ST will be notified of other potential RF channels via management communications.

5.2 Infrastructure Capacity

The following models show typical infrastructure line capacity as a function of:

- RF Spectrum allocation
- Isolated Cell [1] or Contiguous [2] deployment
- Various per line traffic levels, based on 1% GOS (Erlang B)

5.2.1 32kbit/s Telephony

Spectrum Allocated:	10.5 + 10.5 MHz		21 + 21 MHz		42 + 42 MHz	
Cell Configuration	3 - Sector		3 - Sector		3 - Sector	
#RF / Sector	1		2		4	
#RF / Cell	3		6		12	
	[1]	**[2]**	**[1]**	**[2]**	**[1]**	**[2]**
TCH / Sector	52	40	104	80	208	160
Erls. / Sector (1%Gos)	40	29	80	58	160	116
Erls. / Cell	120	87	240	174	480	348

Lines per cell / Traffic (mE)

	[1]	**[2]**	**[1]**	**[2]**	**[1]**	**[2]**
40 mE	3,000	2,175	6,000	4,350	12,000	8,700
75 mE	1,600	1,160	3,200	2,320	6,400	4,640
100 mE	1,200	870	2,400	1,740	4,800	3,480

5.2.2 64kbit/s Telephony or Data Service

Spectrum Allocated:	10.5 + 10.5 MHz		21 + 21 MHz		42 + 42 MHz	
Cell Configuration	3 - Sector		3 - Sector		3 - Sector	
#RF / Sector	1		2		4	
#RF / Cell	3		6		12	
	[1]	**[2]**	**[1]**	**[2]**	**[1]**	**[2]**
TCH / Sector	26	20	52	40	104	80
Erls. / Sector (1%Gos)	17	12	34	24	68	48
Erls. / Cell	51	36	102	72	204	144

Lines per cell / Traffic (mE)

	[1]	[2]	[1]	[2]	[1]	[2]
40 mE	1,275	900	2,550	1,800	5,100	3,600
75 mE	680	480	1,360	960	2,720	1,920
100 mE	510	360	1,020	720	2,040	1,440

5.3 System Capacity Limits

- Up to 2048 Subscriber Terminals (STs) per RF channel.

- Up to 4 RF channels per Central Terminal (CT). Supported by up to 4 x 2Mbit/s links to the host Access concentrator (AC).

- Up to 12 RF channels provisioned in 3 Central Terminals per Cell site. Supported by up to 12 x 2Mbit/s links to the host Access Concentrator (AC).

- The AC supports up to 64x2Mbit/s links to the Switch, for each group of 4 x 2Mbit/s links to the CT.

6 Equipment Details

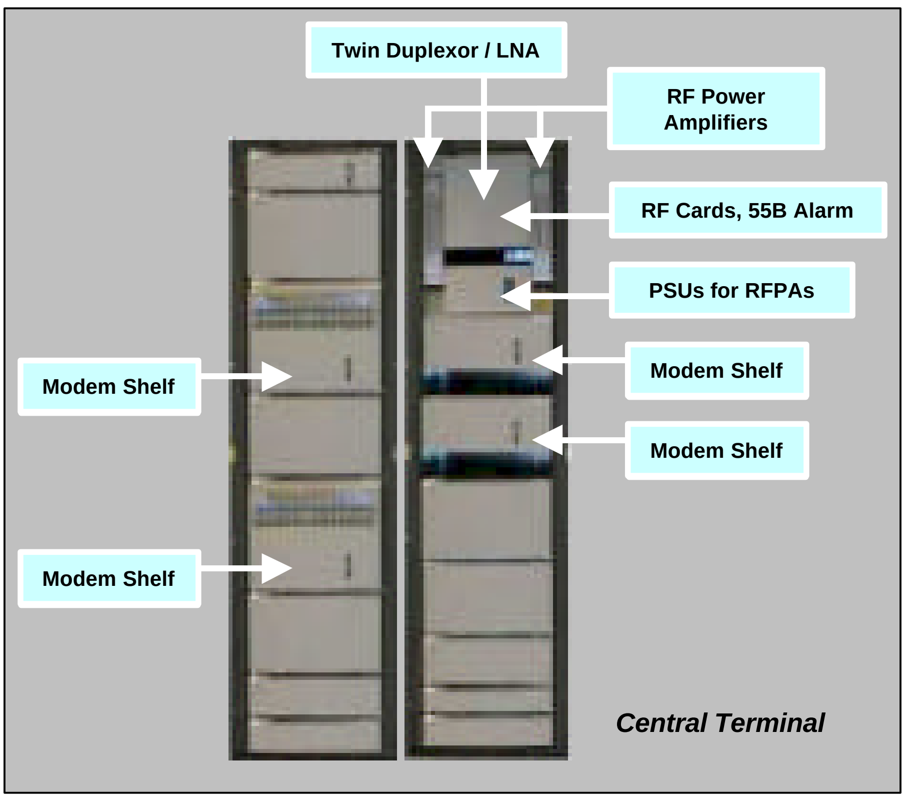
6.1 Infrastructure

All internal CT and AC system components are be packaged so that they fit into an ETSI style equipment practice, 2200mm x 600 mm x 300mm.

The mechanical design is modular and does not preclude the co-location of CT RF / modem shelves and AC shelves.

Up to 4 RF channels (CT modem shelves) share a single RF combiner shelf. There is no forced air-cooling.

Smaller configurations of CTs are also available for custom applications



6.1.1 Temperature and humidity limits

-5 to +45 deg. C. 95% relative humidity.

6.2 Power Requirements

Supply voltages:	-21.8 to -70VDC. -48VDC nom.	
Consumption:	AC Shelf (68 E1 ports):	140W
	CTRF Combiner (4RF):	300W
	CT Modem Shelf:	120W (Up to 4 per CT)

6.3 Antenna Configurations

- Omni antenna assembly
- Directional antenna assembly (65deg.)
- Directional antenna assembly (120deg.)

Typical height of the antenna tower employed is 15m.

The antenna interface is N-type connector, 50 ohm. Provision is made for earthing the RF feeder to the top of the tower and at the building entry point.

6.4 Installation and Commissioning

Up to 5 man-days per CT including rigging of antenna system on an existing tower.

6.5 Subscriber (ST) Equipment

6.5.1 Size

External Antenna	200 x 200 x 20mm
Internal ST (ST-R)	280 x 190 x 35mm

6.5.2 Weight

Internal SIU:	0.7kg

6.5.3 Power consumption

Internal SIU+Antenna:	6W

6.5.4 Battery backup

24V battery backup is typically 4 hours, using standard rechargeable batteries. Charge time is 10 hours. This can be extended by the use of external batteries. Optional solutions are available to extend to 24 hours.

6.5.5 Pay phone Support

Subscriber terminals support 12kHz or 16kHz subscriber pulse metering SPM and polarity reversals.

6.5.6 Ringer loads and drop distances

Ringer load:	REN = 3
VF Drop length:	500m max (cable quality dependent)

6.5.7 ST Antenna characteristics

A common high gain external directional antenna is used for all ST types.

Gain	10dBi to 17dBi
3dB HHPBW	± 80
3dB VHPBW	± 150
Front to back ratio	20dB
Return loss	14dB

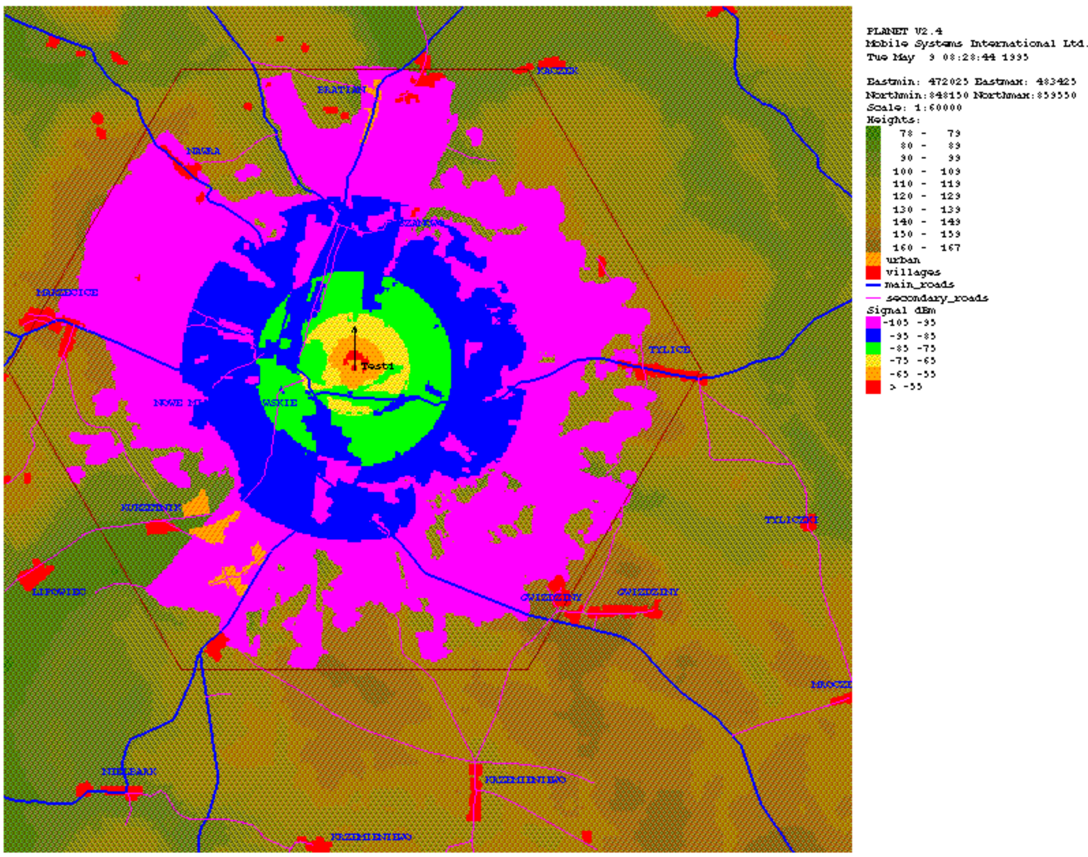
6.5.8 Installation & Commissioning

Approximately 1 hours per ST with suitably trained installation engineers.

7 RF and Deployment Planning

The use of radio to replace the traditional use of copper in the access network requires modifications to an operator's normal deployment planning process, with emphasis on radio coverage and frequency planning aspects.

As an aid to this planning process a fully equipped RF planning tool, called AirPlan™, including all necessary hardware and software can be supplied. The AirPlan™ tool maps end-users to cell-sites based on the anticipated traffic levels.

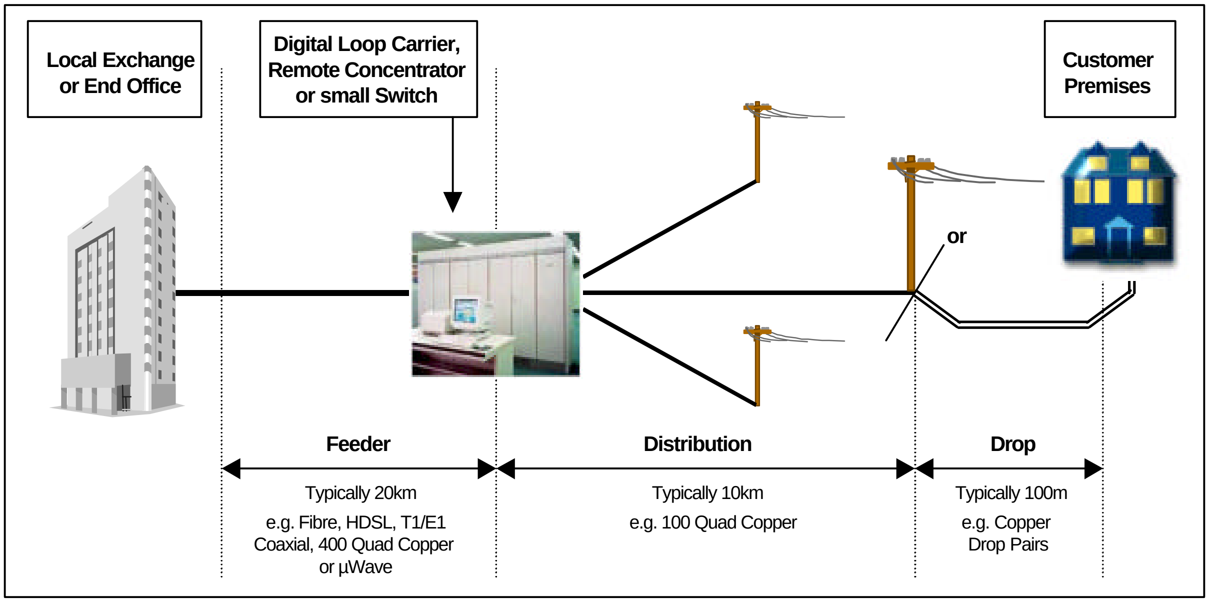


Thorough implementation of the RF planning process will provide an operator with a high degree of confidence that satisfactory radio coverage can be achieved at the desired ST locations from a given CT, or set of CT locations. Due to the nature of radio propagation trees or other buildings in the vicinity of a particular end-user location may affect the signal level at that location. Therefore, the planning process cannot guarantee the viability of an end-user connection, and certain local checks are required prior to the installation of an ST on an end-user's building.

Appendix A. Wireless Local Loop (WLL) background and technology comparisons

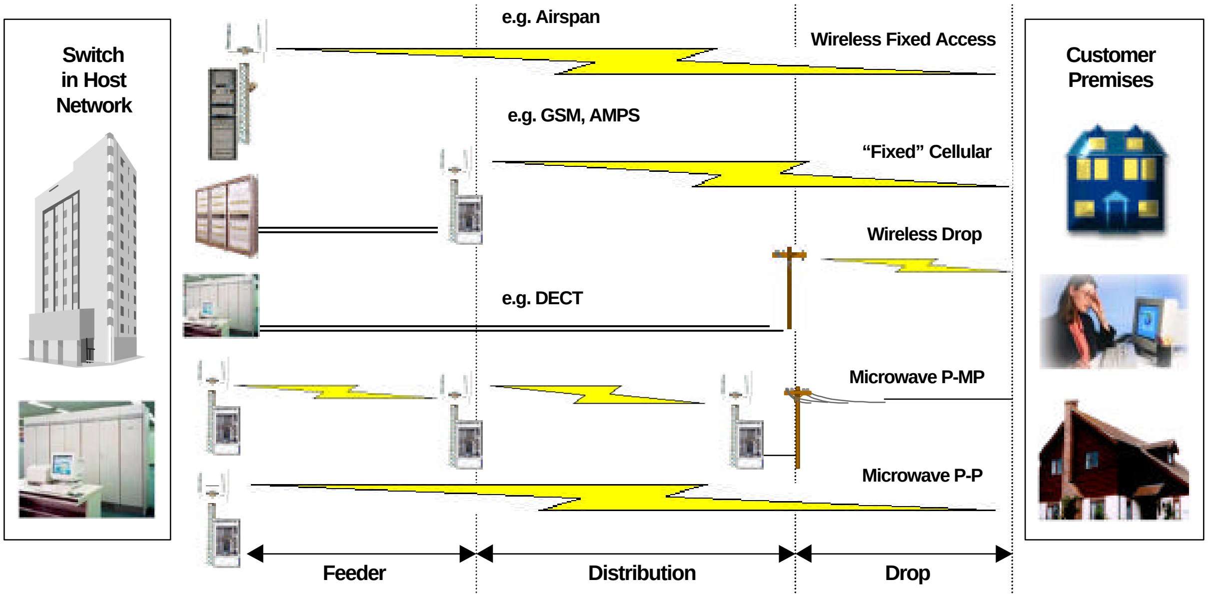
Wireless Local Loop (WLL) is a loose term used to describe the application of radio technology in the local access network, as an alternative to traditional copper pairs between the local exchange and subscribers' premises. However, like most generic terms, WLL covers a very broad spectrum of solutions. Numerous architectures exist, each described as WLL, and each significantly different to the other.

All Wireless Local Loop solutions are designed as an alternative to a copper access infrastructure, as shown below. This "generalised architecture" is globally applicable and represents 99% of all wireline access infrastructures installed around the world today.



This copper access architecture consists of three parts, the Feeder network, the Distribution network and the Drop.

It is generally accepted that five different WLL architectures exist, each is an alternative to all or some of the copper access network architecture shown above. The different architectures are shown below:



Wireless Fixed Access

Wireless Fixed Access is the term used to describe products and architectures that are direct alternatives to copper-based "Wireline" Drop, Distribution and Feeder Networks. These types of systems deliver the same Services, Quality and Grade of Service as copper. Generally they are optimised to substitute copper-based networks in semi-rural (for example Western European Rural) and Suburban environments. This is the architecture supported by Airspan's systems.

Fixed Cellular

Fixed Cellular as the name implies is the application of mobile cellular radio technology to the local loop. These types of system replace the distribution and drop parts of the network, but usually require installation of special base station sites, as the system may be configured to support mobile subscribers as well as wireline replacement. The major disadvantage of fixed cellular is that the equipment was originally designed for mobile voice telephony, and not designed to provide the same services, quality, or grade of service as copper. Fixed cellular is suitable for rural/suburban and urban deployments, and can be planned for in-building coverage. It can also provide full mobility if required.

Wireless Drop is an alternative to copper-based drop segments e.g. the last 100m. This architecture is typically based on cordless telephony technology, such as CT2, DECT or PHS. Because it has a limited range (typically <5km) it is suitable for suburban and urban deployments. In some deployments it can also provide limited mobility. The network cost of this type of solution can be high due to the large number of cells and supporting infrastructure required. Airspan's systems can be deployed to provide a cost effective "backhaul" for these networks.

Microwave Point to Multipoint

Microwave Point to Multipoint is a very mature technology that was developed to provide telephony service in extremely sparsely populated areas. These types of systems are designed to provide long distance feeder and distribution links are specifically designed for this application, and are suitable for very remote, rural telephony. Typically they are low capacity systems, and are configured to provide multiple multi-line drops, rather than drops for individual customer premises.

The last category is **Microwave Point to Point** and is typically used for the direct connection of larger (business) customers to the switching network. This type of system is designed for N x 2Mbit/s distribution and is typically deployed in urban / suburban areas at 10GHz +.

Each of these architectures can be deployed separately or in combinations in an operator's network to deliver the required services to subscribers. Careful assessment is therefore required to determine which technologies are most appropriate.

Appendix B. Vocabulary

AC	Access Concentrator, Central Control Station
ADPCM	Adaptive Differential Pulse Code Modulation. A 32 kbit/s speech CODEC
BER	Bit Error Ratio
CAS	Channel Associated Signalling
CCS	Central Controller Station
C/I	Carrier to Interference ratio
CDMA	Code Division Multiple Access
CLEC	Competitive Local Exchange Carrier
CODEC	COder/DECoder)
CRS	Central Radio Station
CT	Central Terminal
DA	Demand Assignment of air-interface
DASS2	Digital Access Switching System No. 2
DECT	Digital European Cordless Telephony
DS-CDMA	Direct Sequence-Code Division Multiple Access
DSS1	2Mbit/s Switch Interface
E1	European 2Mbit/s line standard
EM	Element Manager
ERP	Effective Radiated Power
ETSI	European Telecommunications Standards Institute
FA	Fixed Assignment of air-interface
FDD	Frequency Division Duplex
GSM	Global System for Mobile Communications
GUI	Graphical User Interface
HHPBW	Horizontal Half Power Bandwidth
ISDN	Integrated Services Digital Network
ITU	International Telecommunications Union
LOS	Line Of Sight
MTBF	Mean Time Between Failure
NLOS	Near Line Of Sight
NTU	Network terminating Unit
OAM	Operations and Management
PA	Power Amplifier
PCM	Pulse Code Modulation
PCS	Personal Communications Services
PHS	Personal Handyphone System
PLMN	Public Land Mobile Network

Vocabulary (Continued)

PN	Pseudo-random Number
POTS	Plain Old Telephone Service
PSTN	Public Switched Telephone Network
PSU	Power Supply Unit
RS	Repeater Station
RW	Rademacher - Walsh (CDMA codes)
SNMP	Simple Network Management Protocol
SC	Site Controller
SPM	Subscriber Pulse Metering
ST	Subscriber Terminal, Terminal Station
TDD	Time Division Duplex
TE	Terminal Equipment
TS	Terminal Station
TCH	Traffic Channel
VHPBW	Vertical Half Power Bandwidth
WFA	Wireless Fixed Access
WLL	Wireless Local Loop

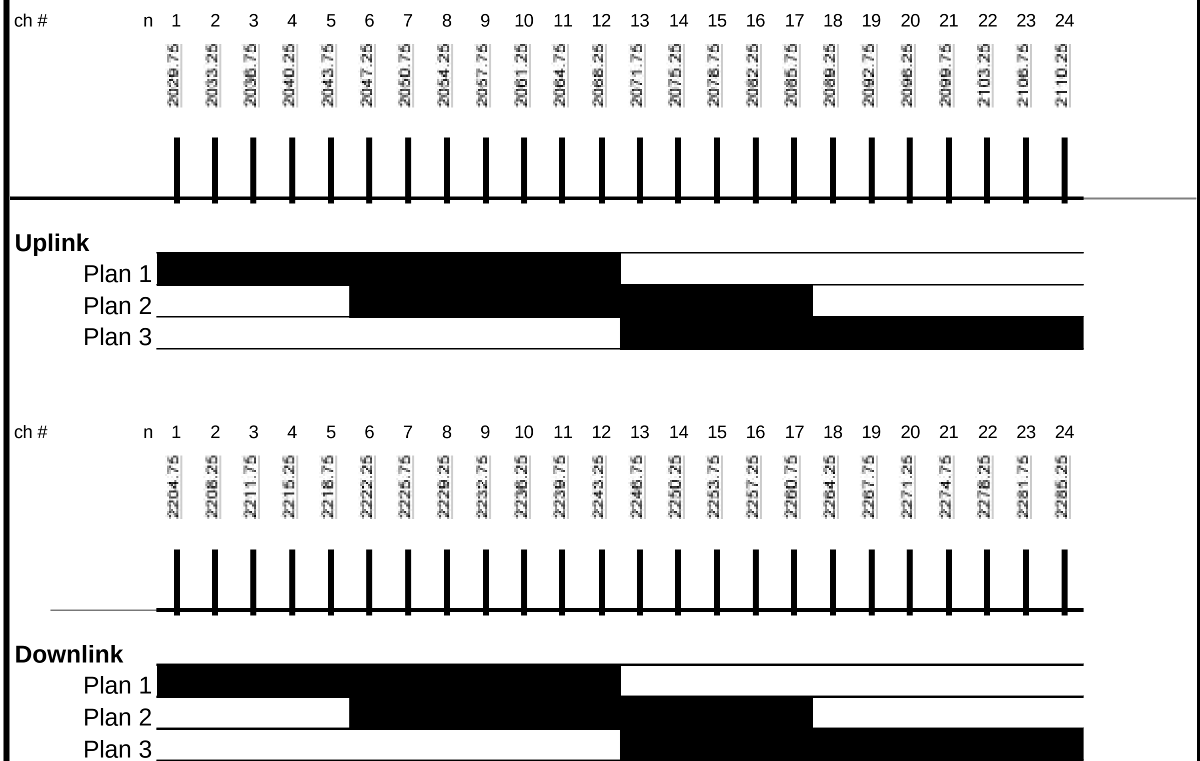
Appendix C.   RF channel plans

Airspan's systems support WFA system implementation in various frequency ranges within the PCS, ITU-R and ETSI 2GHz and 3GHz frequency ranges. The specific implementations currently available operate in frequency bands at 1.8 – 1.9GHz, 2.0 – 2.3GHz, 2.3 - 2.5GHz and 3.4 - 3.6GHz in accordance with the "channel plans" shown below.

The RF channelisation is 3.0/3.5/4.0MHz and Frequency Division Duplexing (FDD) is used. The basic requirement for system operation is for a single RF channel (3.5MHz go, 3.5MHz return), with go-return spacing dependant on the channel plan used.

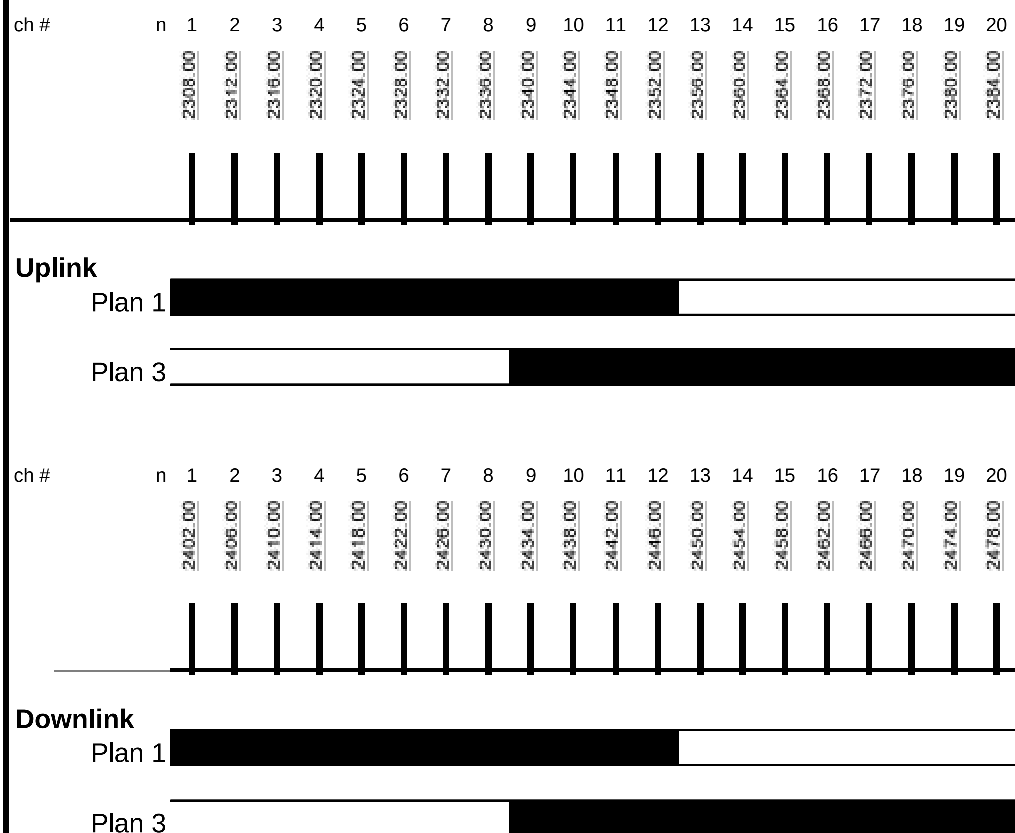
Airspan Frequency Plans for 2.0 - 2.3 GHz
Based on CEPT/ERC rec 13-01 E
Annex C Point to multipoint systems with 175MHz duplex spacing

Fs 2026.25 MHz
Fch 3.5 MHz
Fsep 175 MHz



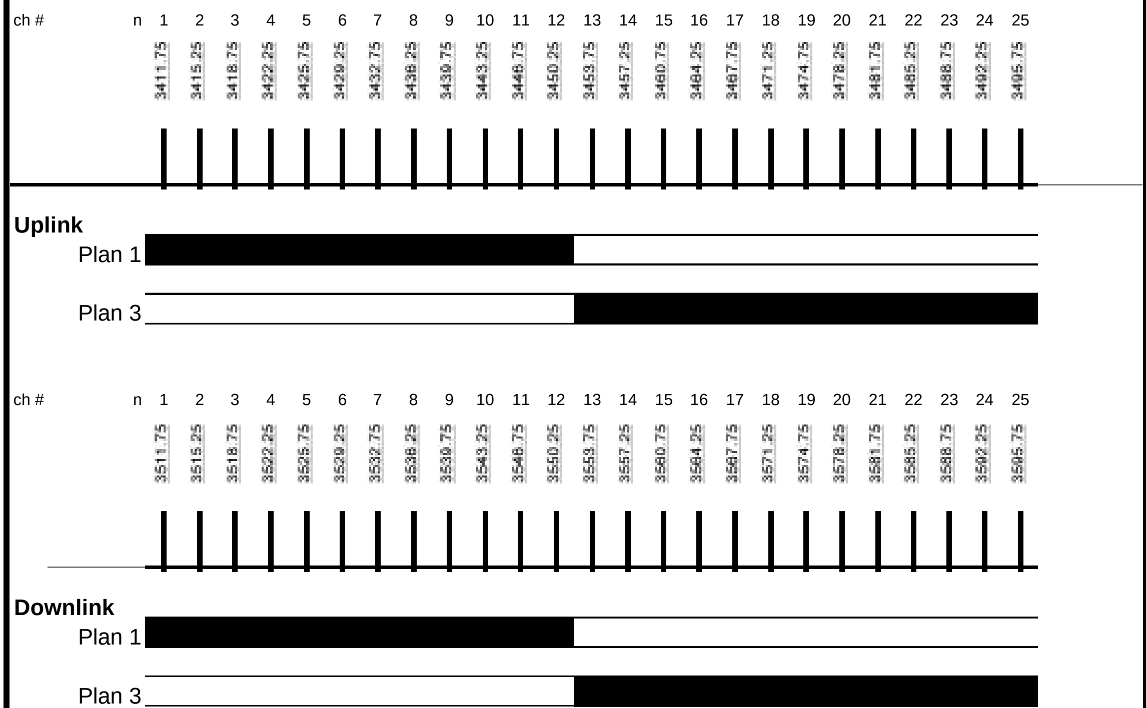
Airspan Frequency Plans for 2.3 - 2.5GHz
Based on ITU rec 746
Point to multipoint systems with 94MHz duplex spacing

Fs	2304	MHz
Fch	4	MHz
Fsep	94	MHz



Airspan Frequency Plans for 3.4 - 3.6 GHz
Based on CEPT/ERC rec 14-03 E (Turku 1996)
Annex B Part 2.2: Point to multipoint systems with 100MHz duplex spacing

Fs	3408.25	MHz
Fch	3.5	MHz
Fsep	100	MHz

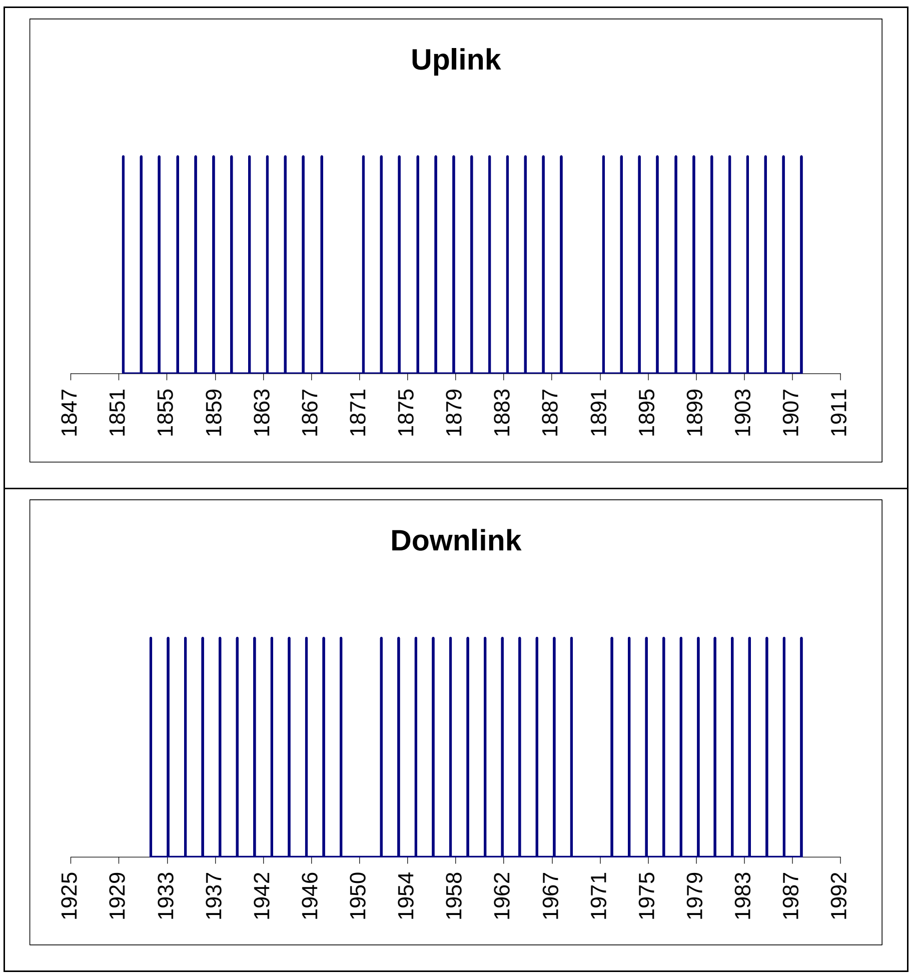


Channel Plans for PCS Band

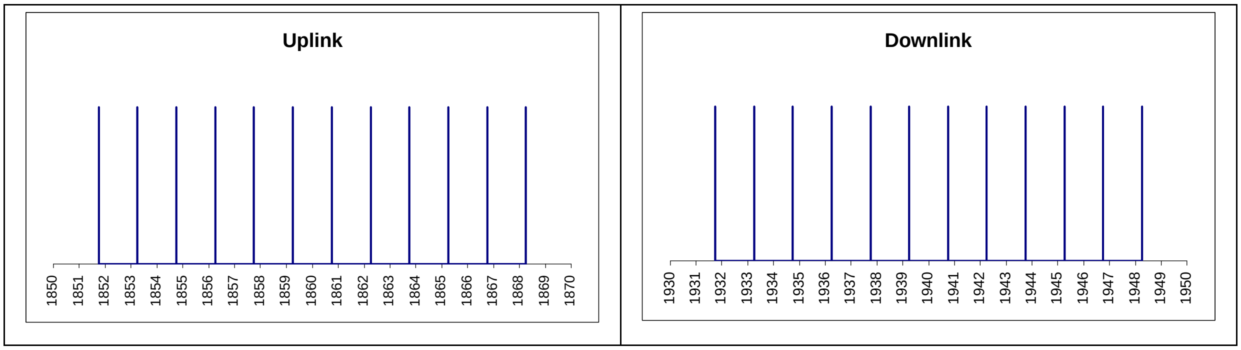
These plans are currently under test to confirm that they meet the FCC emission requirements with RF carriers at 1.75 MHz from the block edges. This is expected to be complete by February 2000.

All PCS band plans have an 80MHz duplex spacing, and individual channels are 3.0 MHz wide. The 1.5MHz channelization shown in these plans indicates possible center frequencies for the AS4000 rf channels. This provides operators with considerable flexibility to optimize spectrum usage within the band allocation(s) that they have been given.

All Plans



1.8 - 1.9GHz, Plan 1 (Covers A and D blocks)

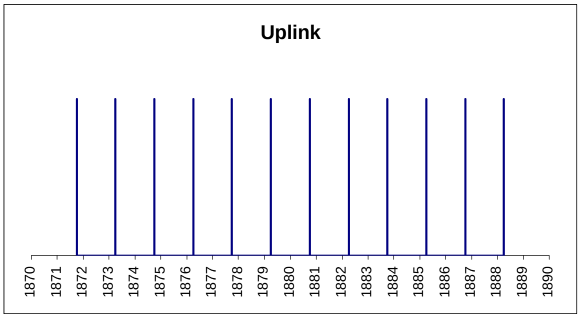


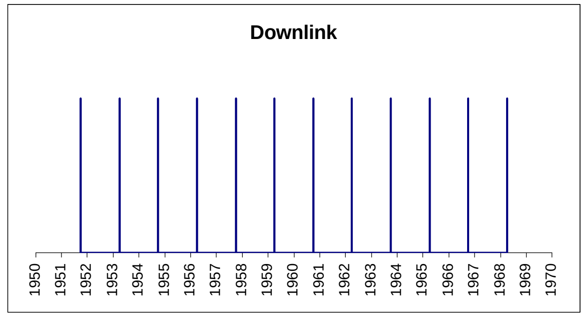
Channel	Uplink (MHz)	Downlink (MHz)
1	1851.75	1931.75
2	1853.25	1933.25
3	1854.75	1934.75
4	1856.25	1936.25
5	1857.75	1937.75
6	1859.25	1939.25
7	1860.75	1940.75
8	1862.25	1942.25
9	1863.75	1943.75
10	1865.25	1945.25
11	1866.75	1946.75
12	1868.25	1948.25

Notes:

- This plan supports 1.5MHz channelization, RF carriers occupy 3 MHz.
- Adjacent channel spacing requirements are subject to cell configuration planning.
- Use of channels 9 & 10 require contiguous A and D block spectrum allocation.

1.8 - 1.9GHz, Plan 2 (Covers B and E blocks)



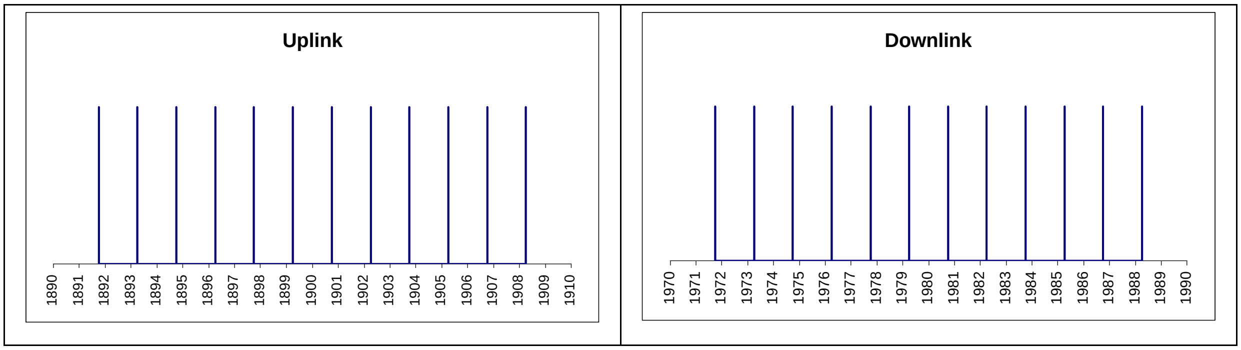


Channel	Uplink (MHz)	Downlink (MHz)
1	1871.75	1951.75
2	1873.25	1953.25
3	1874.75	1954.75
4	1876.25	1956.25
5	1877.75	1957.75
6	1879.25	1959.25
7	1880.75	1960.75
8	1882.25	1962.25
9	1883.75	1963.75
10	1885.25	1965.25
11	1886.75	1966.75
12	1888.25	1968.25

Notes:

- This plan supports 1.5MHz channelization, RF carriers occupy 3 MHz.
- Adjacent channel spacing requirements are subject to cell configuration planning.
- Use of channels 9 & 10 require contiguous B and E block spectrum allocation.

1.8 - 1.9GHz, Plan 3 (Covers F and C blocks)



Channel	Uplink (MHz)	Downlink (MHz)
1	1891.75	1971.75
2	1893.25	1973.25
3	1894.75	1974.75
4	1896.25	1976.25
5	1897.75	1977.75
6	1899.25	1979.25
7	1900.75	1980.75
8	1902.25	1982.25
9	1903.75	1983.75
10	1905.25	1985.25
11	1906.75	1986.75
12	1908.25	1988.25

Notes:

- This plan supports 1.5MHz channelization, RF carriers occupy 3 MHz.
- Adjacent channel spacing requirements are subject to cell configuration planning.
- Use of channels 3 & 4 require contiguous F and C block spectrum allocation.