Broadband Wireless Access

System Description

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Airspan Networks Inc

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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1 Executive Summary

Airspan Network's AS4020 system is a sophisticated wireless point to multipoint fixed Broadband Wireless Access system designed to deliver High Speed Internet connections and Telephony Services.

AS4020 is an evolution of Airspan Network's field proven AS4000 Platform.

AS4020 continues to offer high quality, high capacity voice services, but offers significant efficiency improvements over AS4000 for IP based services.

AS4020 shares a large number of common components with AS4000, and can therefore be deployed separately, or as part of the same Base Station. This minimises the cost of upgrading an existing AS4000 system.

AS4020 is designed for Network Operators and Internet Service Providers who wish to offer premium services; the system is ideal as either an enhancement to existing network (Wired or Wireless), or as a platform to deploy a completely new network. AS4020 operates in various licensed frequency bands from 1.8 to 3.6GHz ensuring the maximum coverage of fixed access radio spectrum available to operators today.

AS4020 can be 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 wired services, by supporting transparent connections to the operator's network.

The services offered by an Airspan AS4020 system will be perceived by end-users as a **Wireless DSL** solution. It provides customers with combinations of Voice Telephony and an always-on high speed Internet connections, very similar to capabilities of wired DSL solutions.

Each AS4020 system comprises:

- Subscriber Terminals (STs), which offer a wide range of service combinations on a single customer interface unit, including data only terminals, integrated data and voice terminals, and voice only terminals. Voice only and Integrated Voice / Data Terminals can have up to 4 voice lines.
- Central Terminals (CTs), Airspan Network's radio base stations. These provide the radio links to the STs and the connectivity to the access concentrator (if required).
- Access Concentrators (ACs) provide the traffic concentration and switch interface functions for voice. AS4020 Base Stations can operate without the AC via a local IP interface if only packet data services are required.
- Network Management System (Netspan AS8200) offers configuration, alarm, test and performance information for the both AS4020 and AS4000 BWA systems
- RF planning tool, AS9020 Airplan, supports all of the functionality required to plan the deployment of an AS4020 system. It can also be used to plan single or mixed deployments of Airspan Network's other radio products.

AS4020 also has a set of advanced facilities to enable ISPs to manage Point of Presence Traffic over the BWA network. It offers sophisticated Quality of Service (QoS) solutions intended to manage Service Level Agreements based on configured throughput and prioritisation rules, and provides traffic statistics plus easy interfacing to customer care systems.

Voice support can be on voice only terminals (1,2 and 4 lines), or Integrated PacketDrive Voice and Data terminals, with 2 or 4 lines per terminal plus a high speed Internet connection. AS4020 offers fully transparent voice capability enabling each voice circuit to carry Fax and In-band modem traffic if necessary.

An entry level system can operate a single 3MHz RF Channel via an omni or directional antenna. This system can be expanded from this level up to 24 RF Channels at a single site.

At the entry level for pure voice applications, the system would support, for example, around 450 80mErlang ADPCM users. This could be expanded to support around 10,800 similar users.

At the entry level for pure data applications, the system would support, for example, around 340, 512kbit/s DSL users. This could be expanded to support around 8160 users.

Airspan has a well established track record. Airspan has deployed systems that support numerous applications within both existing and new telecommunications networks and has been deployed in both developed and developing country environments. In mid 2003, Airspan Networks had installed over 1,000,000 lines of capacity and has over 100 customers in more than 60 countries.

2 Product Overview

The AS4020 Broadband Wireless Access (BWA) system is a digital point to multipoint radio access system providing wireless access for fixed end-users to a telecommunication operator's network.

AS4020 is specifically designed for mixed voice and data Wireless DSL applications. AS4020 delivers two types of service, carrier class voice telephony and packet-oriented interfaces for always-on Internet connections. Distances up to 70km can be covered. AS4020 is therefore an attractive alternative to traditional copper "local loops" for the delivery of DSL services to end-users.

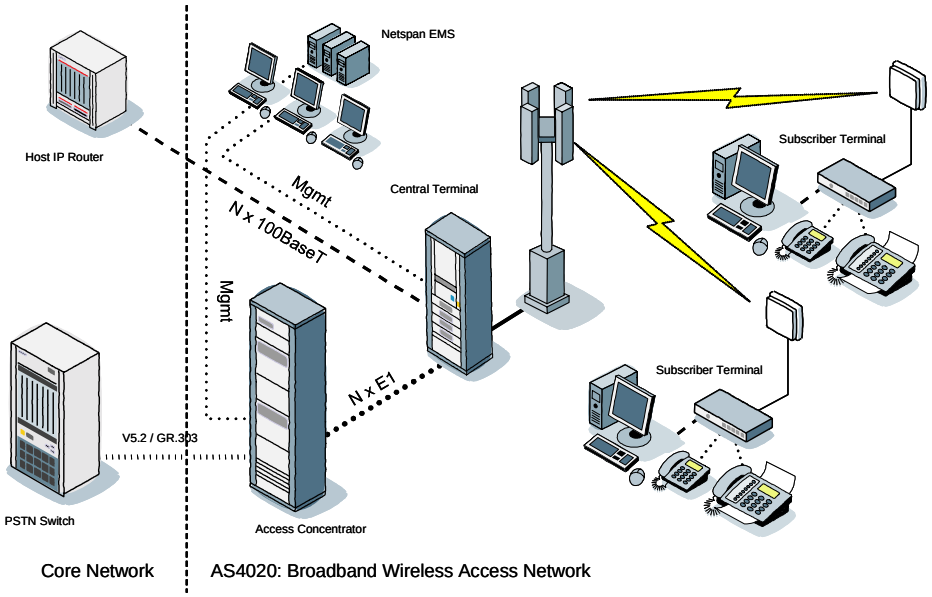


Figure 1. AS4020 General System Architecture

AS4020 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 be the IP switch location or conventional telephony local exchange. 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 cabin, and connected to the local exchange via radio, cable or fibre digital transmission links. This is the approach adopted when deploying contiguous coverage cellular networks.

2.1 AS4020 Service Capabilities

Mixed Voice and Packet (IP) Services are supported by a single Subscriber Terminal (ST). Voice connections are made via standard RG11 sockets and data connection is through an RJ45 Ethernet interface.

2.1.1 Voice Services

- Voice Telephony: 1, 2 and 4 lines per Terminal (Transparent to Super G3 Fax and V.90/92 Modem Data at 56kbit/s)
- Bit error rates: Typically better than 1×10^{-6}.
- Transmission delays: One way system delays are below 5ms, having a minimal impact on all voice applications, and completely removing the need for Echo Cancellation.

2.1.2 Packet Data Services

- Individual Subscriber Packet Data Rates: Up to 2.3 Mbit/s downstream (from Base Station), and up to 1.5 Mbit/s Upstream (to Base Station).
- Bit error rates: Typically better than 1×10^{-6}.
- Transmission delays: Minimum one way system delays are below 50 ms, having a minimal impact on data applications (excluding IP packet forwarding delays).

2.1.3 Access to the Internet

High speed data access on a packet switched basis operates at various rates. The bit rates achievable per 3MHz RF Channel are shown in the following table. Each individual ST is dynamically characterised to determine optimum transmission rate dependent on the radio link quality. This ensures that the spectral efficiency is maintained even when a number of STs are operating at the extremities of link budget.

Radio Channel Throughput				
Propagation/Radio link Conditions	**Downlink Radio Channel**	**Downlink Per Subscriber**	**Uplink Radio Channel**	**Uplink Per Subscriber**
Poor	2.4 Mbit/s	768 kbit/s	2.4 Mbit/s	768 kbit/s
Intermediate	5.6 Mbit/s	1.5 Mbit/s	5.6 Mbit/s	1.5 Mbit/s
Good	8.5 Mbit/s	2.3 Mbit/s	5.6 Mbit/s	1.5 Mbit/s

Table 1 *AS4020 Packet Data Thru-put*

2.2 Market Segments Addressed

Airspan Network's AS4020 system is targeted at areas where there is a growing demand for integrated high speed data and voice services, and where cost considerations make traditional solutions impracticable.

- In developed markets, this is typically characterised by the high-end residential market, or SOHO (Small Office / Home Office), and the small business market or SME (Small to Medium Enterprise).
- In the developing world, where the existing communications infrastructure is not as well advanced, Airspan AS4020 wireless solutions can be the basis for a new high quality national infrastructure.

2.2.1 Internet Service Provider (ISP)

Internet Service Providers with access to licensed radio spectrum can use the AS4020 system to offer reliable high speed, high capacity internet services. AS4020's excellent frequency reuse allows contiguous network coverage with minimum use of radio spectrum. With the AS4020, an ISP can also move into offering VoIP or analogue telephony in conjunction with Internet access to enhance their service provision.

2.2.2 Competitive Local Exchange Carrier (CLEC)

In both developed and developing countries, the CLEC can use the AS4020 to provide a "local loop bypass", allowing the 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 and the operator is not reliant in any way upon the Incumbent Carrier.

2.2.3 Incumbent Local Exchange Carrier (ILEC)

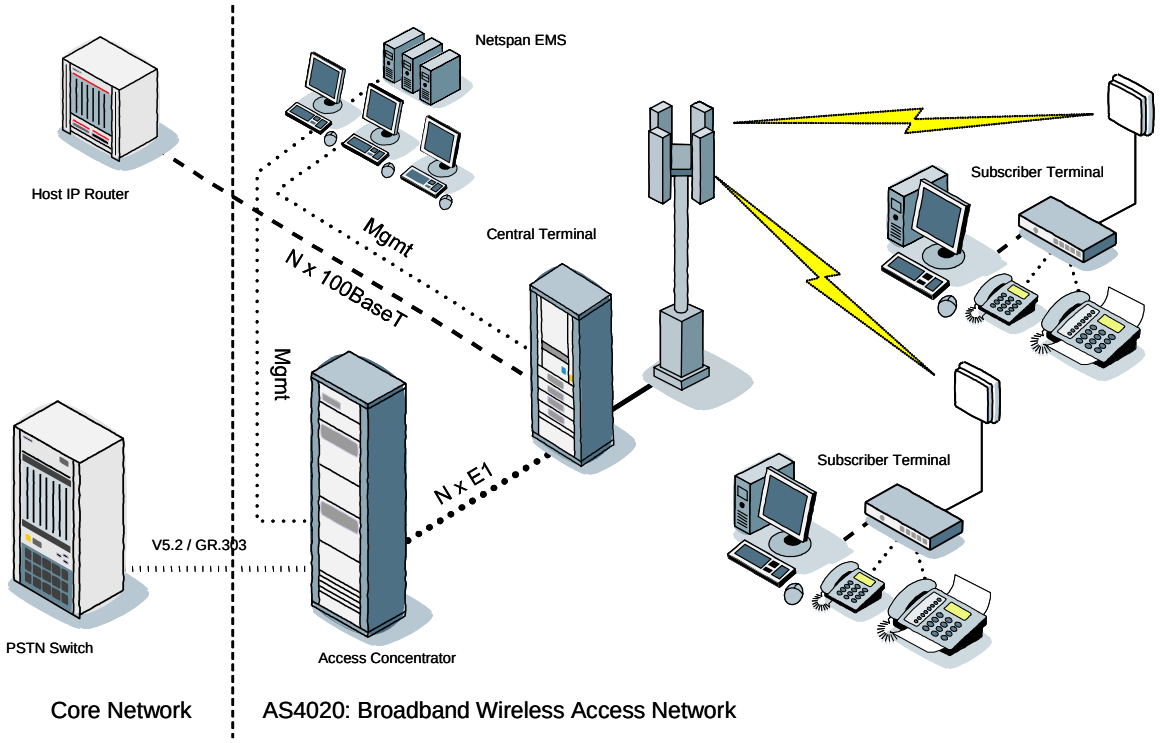
As the Incumbent Carrier, the ILEC has an obligation to provide telecommunication services. In developed countries the AS4000 and AS4020 systems can be used as a "copper alternative", to complement the existing access networks, reduce operating costs and thus reduce the cost of universal service provision.

2.3 System Architecture

2.3.1 AS4020 Equipment Overview

The AS4020 system consists of four main network elements:

- The Central Terminal (CT) located at the radio site or at the switch site.
- The Access Concentrator (AC) normally located at the switch site (not required for data only applications)
- The Subscriber Terminal (ST) located at the end-user's premises.
- The BWA Management system consists of AS8200 clients, located at an Operator's network management centre, with AS8200 Netspan servers connected to the AC and CT equipment.



Central Terminal

A Central Terminal (CT) Rack contains all modem and RF Transceiver functionality for up to four 3MHz Radio Channels. One or more CT Racks are deployed per Base Station site. A Basestation can be deployed in omni or sectored cell configurations supporting variable numbers of STs per cell. The AS4020 CT is a multi-service platform hosting Packet services and multiple line telephony.

For voice support, the CT is connected to the Access Concentrator via 2Mbit/s (E1) or 1.5 Mbit/s (T1) interfaces. For IP data support, the CT is connected to the Service Provider's IP network via 10/100 bT Ethernet interfaces. CT management traffic may be connected via the same Ethernet as data traffic or via a separate management port.

AS4020 supports up to 4 Radio Channels per Rack.

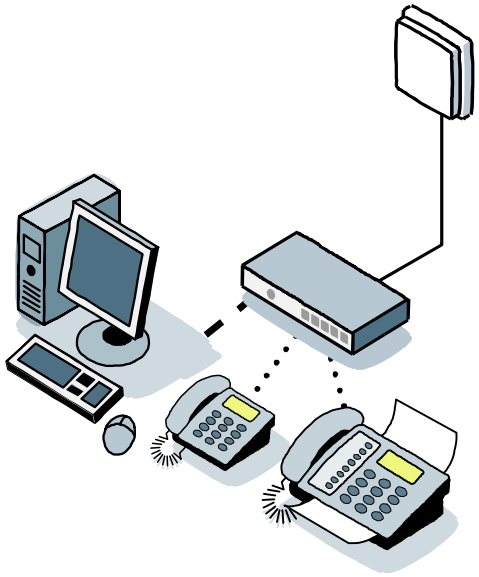
2.3.1.1 Access Concentrator

The Access Concentrator (AC) is required to de-multiplex the voice traffic concentrated on the air-interface for presentation to the network switching and routing equipment. It also performs decompression of 32kbit/s voice services to standard 64kbit/s for integration into conventional circuit based telephony networks.

AS4020 networks do not require the AC for data only applications. If voice support is required, an AC must be deployed.

2.3.1.2 Subscriber Terminals

The architecture of the ST comprises three principal units. The outdoor unit (ODU) contains a directional antenna and RF transceiver. This is small, light and easy to install. The Service Interface Unit and power supply are situated indoors.



The Service Interface Unit (SIU), is normally located at a convenient position within the end user's premises. The SIU is connected to the ODU by a coaxial drop cable. A mains powered PSU (optional battery backup) completes the installation. Airspan supplies a handheld installation tool known as STMeter, which is used in conjunction with a standard telephone handset for single person installations of the subscriber terminal. A PC based software package, STMon, is also available for maintenance purposes.

Various battery backup options are available, offering standby times suitable for "lifeline" services.

Four types of STs are supported by the AS4020 System. They are:

- ST P1V2 providing a single Ethernet packet port and two POTS ports.
- ST P1V4 providing a single Ethernet packet port and four POTS ports.
- ST V1 providing a single POTS port.
- ST V2 providing two POTS ports.

2.3.2 BWA Network Management System

The Airspan AS8200 Management system monitors, tests and configures the AS4000 and AS4020 based networks. AS8200 Netspan System Managers are scaleable, distributed PC based management systems that are used for full-scale management including integration with an operator's OSS system. It is capable of fault localisation, subscriber line tests and status reporting and with its intuitive user interface, makes configuring the network very straightforward.

The AS8200 is designed around the FCAPS principle (see Figure 2), with access to the various functions configurable for different user groups.

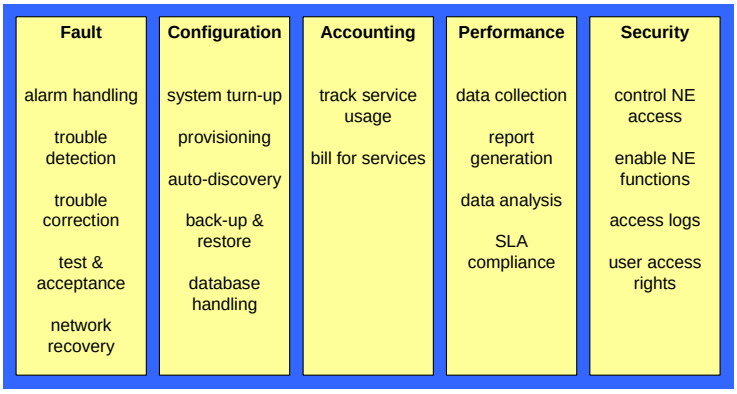


Figure 2: AS8200 Management Services

AS8200 runs on Windows 2000 & XP Server as a server that is accessed by operators from remote PCs using a browser such as Microsoft Internet Explorer.

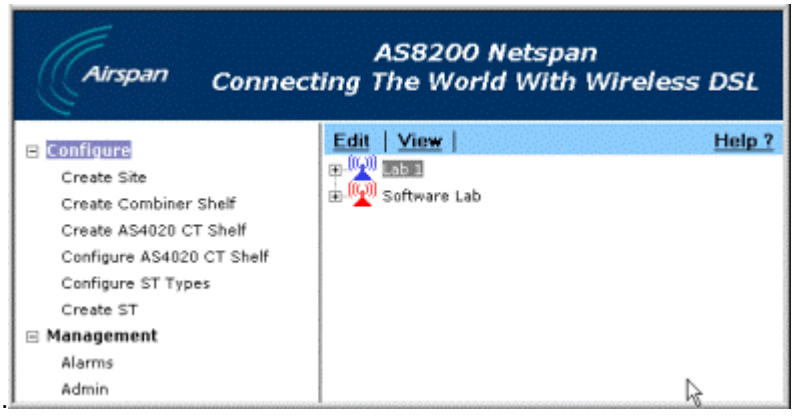


Figure 3: AS8200 Browser Interface

2.3.3 AS4020 Operation Overview

The AS4020 system Radio Interface structure has been designed to optimise mixed support of both circuit and packet orientated services. The air-interface protocol and structure is compatible between both types.

AS4020 radio interface is an evolution of the field proven AS4000 system, and introduces a new operating mode, known as BDM (or Block Data Mode). Block Data Mode is key to the improvements made in data handling efficiencies. It provides a payload mode optimised for delivering mixed voice and packet data, and permits higher bandwidth channels and improved throughput efficiency for packet services.

In addition AS4020 also supports two new modulation states, known as QAM16 and QAM64. These higher order modulation levels provide improved spectral efficiency (where radio link budget and quality allows). Variable Forward Error Correction (FEC) coding methods are supported to optimise data throughput dependent on the radio channel bit error rate. Modulation and FEC are continuously monitored and modified as required for each ST individually to maximise data throughput. AS4020 also improves the performance in very difficult deployment environments (Non LOS conditions) by adding linear equalisation.

The air interface is divided into two portions, one for voice and one for data. The boundary is dynamically adjusted according to the current voice and data loads. This ensures that the maximum voice and data capacities are available at any instant.

AS4020 is Airspan Network's 3rd Generation CDMA technology, with numerous patent applications pending.

2.3.4 AS4020 Operational Modes

The AS4020 supports two payload modes that may be used simultaneously on a radio channel:

- Circuit Switched Voice Mode
  - Provides high quality voice services (similar to AS4000) that are able to transport V90/92 modem calls and fax calls.
  - Optional 32 kbit/s ADPCM compressed voice support for higher capacity.

- Block Data Mode (BDM)
  - BDM is a MAC optimised for efficient packet transport in both the forward and reverse directions.
  - Supports non-contention based uplink access for superior COS/QOS management.
  - Each block of data is coded with modulation and coding rate based on the current measured quality of received signal.

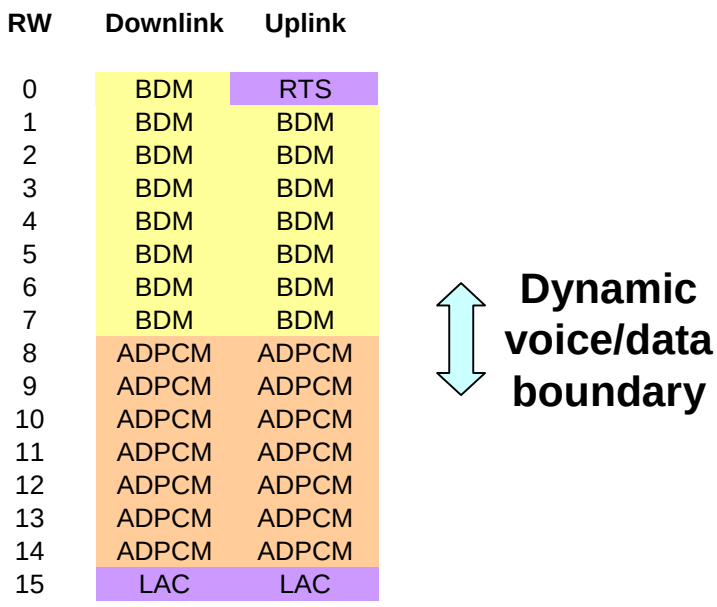


Figure 4 *AS4020 Radio Interface Structure*

2.3.4.1 Circuit Oriented Operation

The operation of voice based services on the AS4020 radio interface is similar to the operation of the AS4000 product. AS4020 supports a full "Demand Assigned" Radio interface, which makes a temporary call-by-call assignment of channels to Subscriber Terminals for telephony applications. This allows the provision of Graded Service based on normal telecoms traffic engineering.

Within each RF Channel a pool of traffic channels (TCH) supports a mix of 40 and 80 kbit/s services. Pool management is configurable, so that payloads of 32 and 64kbit/s can be provided on demand.

The protocol can also support one or more priority channels allowing guaranteed access for emergency calls.

The channels allocated to telephony traffic are pooled and configured as combinations of:

- up to 26 x 64kbit/s,
- up to 52[1] x 32kbit/s.

AS4020 voice applications sends OAM and Call Control messages in a packet message structure, along side pure packet data communications.

[1] AS4000 modem shelves support up to 52 channels, AS4020 modem shelves support up to 48 channels.

2.3.4.2 Packet Orientated operation

AS4020's uses Block Data Mode to carry IP traffic within the same air interface as the voice traffic.

Block Data Modes operates as follow

- Each Block is sent with a fixed 4 msec duration
- Each frame comprises Header, Control and Data portion
- There are no restrictions on frame ordering
- Each Frame can be sent in a different modulation state, with different modulation / FEC.

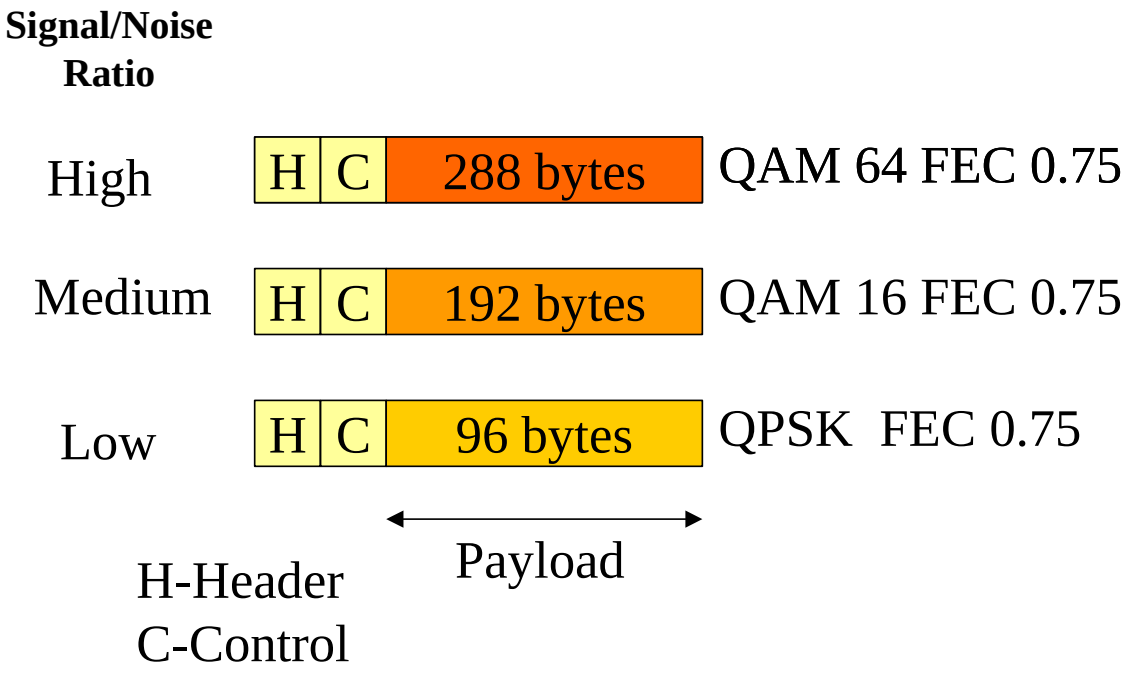


Figure 5 *AS4020 BDM Operating Modes*

BDM payloads enable users to enjoy high speed Internet access at up to 2.3 Mbit/s per subscriber.

The dynamic adaptation of the AS4020 radio interface means that an AS4020 network is continuing changing. This dynamic modulation / FEC optimises throughput for a given environment. Packet Data RW codes (operating in BDM) may be modulated QPSK / QAM16 / QAM64 with FEC of 0.5 or 0.75 on a per ST management poll basis.

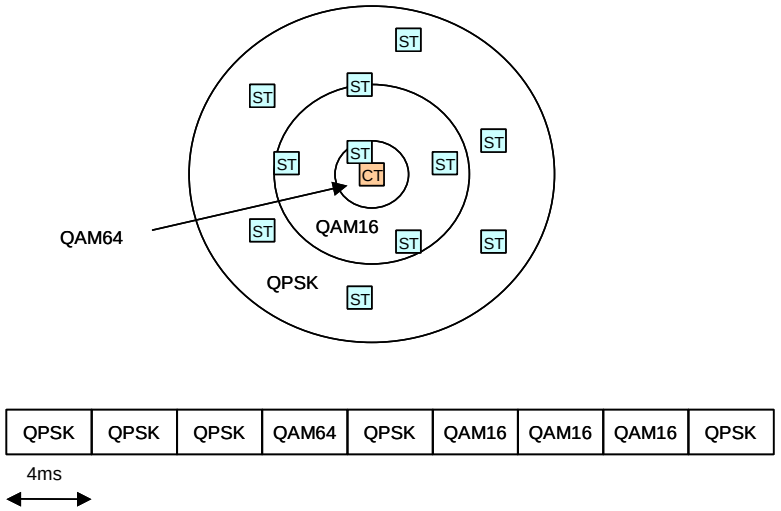


Figure 6 *AS4020 per ST Modulation & FEC Adaption*

Each ST receives it's BDM frame of information in a modulation, FEC and spreading rate that is compatible and optimised for that ST's individual radio link performance. STs on lower quality/longer range radio paths operate in QPSK and QAM16 states. High quality/shorter range links operate in QAM16 and QAM64 states. Forward Error Correction also dynamically adjusts, constantly maximising the end-users delivered data rate.

2.3.5 AS4020 QoS and CIR Management

Sophisticated Quality of Service measures are provided by the inbuilt AS4020 QoS monitoring and control.

2.3.5.1 Grade of Service

AS4020's GoS feature set allows different service levels to be offered directly by the AS4020 radio interface. This permits the operator to tariff for the service grades. The GoS feature is based on a technique called Priority Filtering. Priority Filtering can be enabled at the following levels:

- IP or MAC address : All traffic to/from a particular IP or MAC address has the same priority.
- ST Port: All traffic to/from a particular ST port has the same priority unless overridden by a different priority setting for traffic to/from a MAC or IP address. A priority filtering setting is defined for each ST port.

Priority Filtering operates on a packet-by-packet basis, every packet has an assigned priority level. The priority level for the filtered packet enables the AS4020 to handle:

- High - Real time packets sensitive to throughput delay and jitter
- Medium - Packets sensitive to throughput delay
- Low - Best effort packets

AS4020 packet priority defines the priority or ordering for transmission on the upstream or downstream. The packet transmission order algorithm also ensures that Low priority packets are not totally blocked during periods of congestion.

2.3.5.2 Maximum Information Rate (MIR)

MIR applies to all traffic to/from a particular ST. An MIR setting is defined for each ST in the range 64kbit/s up to the maximum possible value (Peak Information Rate - PIR) which will be determined by radio planning and actual system performance.

MIR is enforced by the AS4020 by throttling of traffic. This ensures that a single ST cannot send or receive data at a rate higher than that defined by its MIR.

2.3.5.3 Committed Information Rate (CIR)

CIR configurations are made for each ST. CIR is configurable in the range of 0kbit/s to the MIR configured for that ST. To ensure that CIR is achievable, the CIRs for each ST connected to the packet service are summed by the management system and compared to the maximum provided. The maximum provided is then calculated from the number of RW codes allocated to the packet service and the MIR configured for each ST using the service.

The CIR for each ST also allowing a degree of overbooking, this takes account (and benefit) of the statistical nature of the packet load. The overbooking ratio is configured via the management system.

In practice, the AS4020 ensures that a CIR allocated to an ST is maintained as a minimum. This is achieved by temporarily increasing the priority of the ST's packet transmissions if the ST is transmitting/receiving traffic above the CIR rate and it appears that the AS4020 load will not allow that CIR to be maintained. Of course if a CIR cannot be maintained, an alarm is raised in the management system.

2.3.6 IP Security – VLAN

The AS4020 supports IEEE 802.1q VLAN. This feature allows groups of Subscriber Terminals to be created, with each group providing a Virtual Private Network (VPN) function, typically for business applications. STs within a group (specific VLAN id) can intercommunicate. Communication across group boundaries is prevented by the AS4020, so maintaining VPN security.

2.4 System Interfaces

Interfaces between the various elements of Airspan Network's AS4020 systems are as follows:

2.4.1 The Central Office / Exchange Interface (Voice Services)

The Access Concentrator (AC) provides the primary network interface between the AS4020 system and the host circuit based telephony switch. This is an N x 2Mbit/s, as per ITU recommendation G.703, short haul 6dB or an N x 1.544Mbit/s as per GR303 T1.

All of AS4020 signalling is digital, and is based on either Channel Associated Signalling (CAS) or Common Channel Signalling (CCS) protocols. Support for 2-wire VF interfacing is via external channel bank equipment. The Signalling systems supported by AS4020 are identical to the ones supported by AS4000:

- Channel Associated Signalling. Support for timeslot 16 ABCD bit CAS is provided. Airspan Network's management systems allow for flexible configuration of the protocol, to interface with switches from various manufacturers including Ericsson, Nortel and Siemens.
- Common Channel Signalling. V5.1 and V5.2 are supported by the DA system.
- 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 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 POTS services. The AC supports V5.2 groups of up to 16 E1 links.
- GR303 / T1 interfaces are also supported, providing POTS services.

2.4.2 IP Switches or Routers (Data Services)

- For operators deploying AS4020, the network-side interconnect consists of N x 10/100Mbps Half/Full Duplex Ethernet interfaces with RJ45 jacks via standard CAT5 Ethernet cable. These connections are available at the Base Station site (directly from the AS4020 CT).

2.4.3 The Radio (Cell) Site (Backhaul Requirements)

The network-side (backhaul) interface from the AS4020 Central Terminal is a single 2Mbit/s G703 / G704 interfaces (E1) or 1.544Mbit/s (T1) for voice applications. These are connected to the Access Concentrator. These links contain concentrated and compressed Voice. See Figure 7.

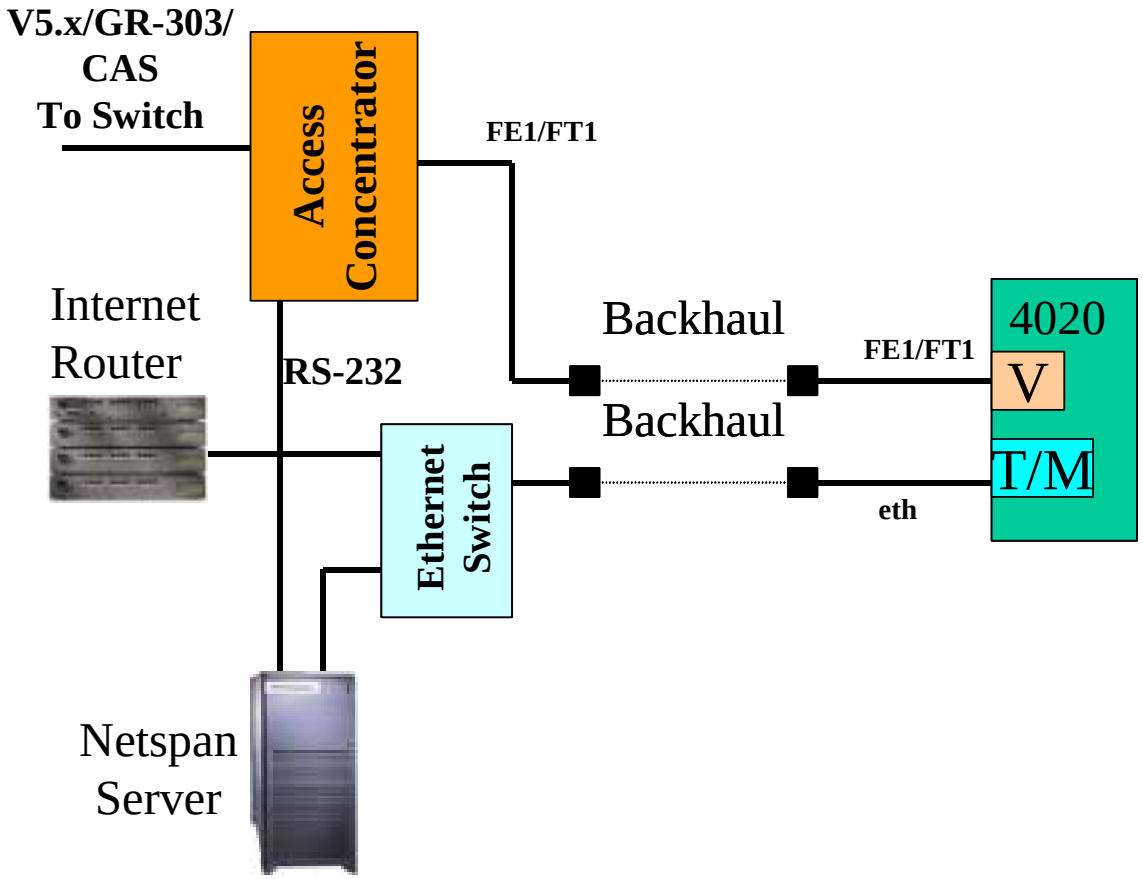


Figure 7 - AS4020 Backhaul Connections

2.4.4 The Network Management System

The BWA Network Management System consists a (AS8200 Netspan SQL) client/server network. The AS8200 is connected to the AS4020 system at both the AC and the CT. These connections allow management of an entire network.

AS4020 management systems were developed specifically to address the needs and operational procedures of a carrier class telecommunications operator. Using radio bearers to provide fixed telephony services introduces a number of new challenges that demand new levels of “manageability” within any BWA product.

Each Subscriber Terminal with an AS4020 network is accessible via an embedded management communication channel, permanently connected to the management system. The subscriber terminal reports its status, and all operational parameters at intervals determined by the operator. Some of the events and operational parameters reported include;

- Line Status (on/off hook)
- Link Availability
- PSU status
- Switch to battery
- Low battery
- Receiver Signal Strength
- Transmit Output Power (under power control)
- Link BER Measurements (Uplink and Downlink)
- Packets Transmitted and Packet Received

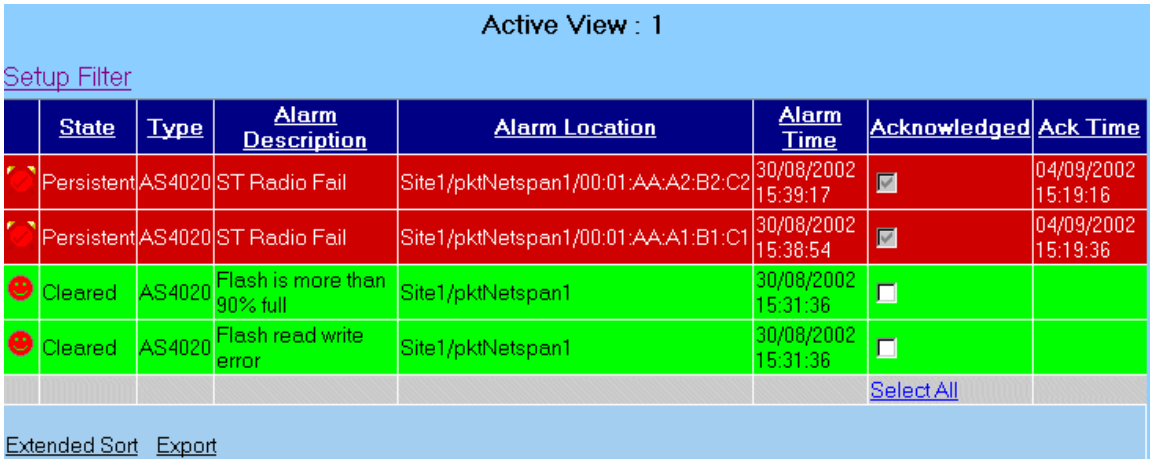


Figure 8 *Subscriber Terminal Management Information Screens*

Access to this level of detailed management (on a per Subscriber Terminal basis) makes it easy to diagnose operational problems. However this is not the only facility available.

AS4020 voice terminals have been designed to mimic the functionality commonly available on VF line cards in modern digital exchanges. AS4020 voice and integrated voice and data packet terminals supports numerous line tests, essential to the cost effective management of any sophisticated network. Such tests include;

- Subscriber Line Test: The subscriber A/B wires are checked for Earth leakage. The Earth needs to meet the recommended earth impedance to pass test. If Earth leakage is detected then the management system is informed and the test is aborted. Otherwise the test continues and the presence of subscriber equipment is checked. The Management system is informed of the result, socket only' or 'Phone presence detected' or test inconclusive.
- Dial Tone: A simulated off-hook condition is generated in the subscriber line interface. Dial tone detection is enabled. The delay in detecting dial tone is sent to the management system as a value in milliseconds. The simulated off-hook condition is removed from the subscriber line interface and the test completes when the set-up condition is fully released.
- Dialled Digit: The Dial Digit Detect test starts with the application of an Intrusion tone to indicate that the management system is ready to receive digits. The Subscriber dials to produce Loop disconnect or MF4 digits these are detected at the ST and are communicated to the management system, one digit at a time. This test may be activated on a subscriber line which is in either the Monitor or Speak and Monitor modes.
- Ringing/ring Trip: The Ringer is activated by a command from the management system. Ringing voltage may only be applied after the Phone goes on-hook. This test requires a test clerk and a customer to answer the phone. When ring trip is detected this event is communicated back to the management system and the test is terminated.

Other facilities available via management command include the ability to apply "Circuit Loop-backs". This loop-back enables any voice/data channel (64kbit/s bearer) to be digital looped at either the Subscriber Terminal, back to the Base Station, or at the Base Station, back into the Subscriber Terminal. The system can then sequentially write test bytes into any associated channel and checks that each test byte is looped back correctly.

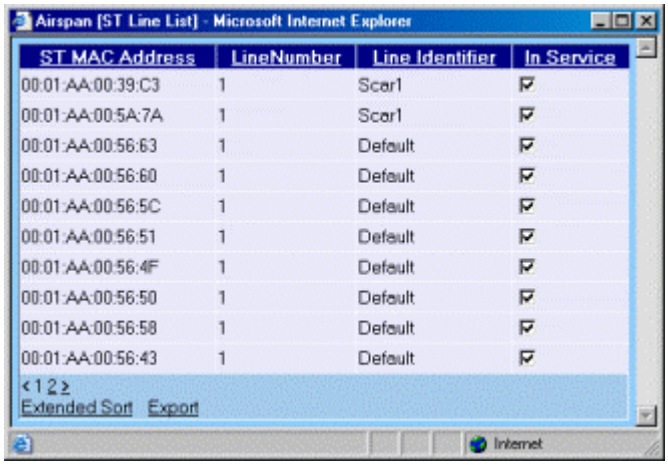


Figure 9 *ST Line Status Display*

The single purpose of all the functions listed is to enable AS4020 to be maintained via remote, centralised management centres, and remove the need for field personnel to visit the Customer Premises. Studies with existing customers (both ILECs and CLECs) have shown that this level of functionality can deliver very significant yearly operational savings when compared with cost of maintaining copper based access or other Broadband Wireless Access networks without this functionality.

2.4.5 AS8200 Capabilities

AS4020's management systems simplify the handling of alarm management, performance monitoring and fault localisation.

Protocols supported	TCP/IP
Data logging	All transactions (client-server-equipment messages and alarms) User can generate custom log types
Security	users assigned to groups providing various access rights
Line capacity	typically up to 10,000 lines per server, expandable to 500,000 line networks
Max no. of clients	5 per AS8200 server
Link failure detection	radio links and communications

2.5 Future Product Enhancement

Airspan Networks is committed to development of broadband wireless access solutions for communications service providers globally. The drive towards broadband is dominated by the demand for high-speed access for Internet applications – be that voice, data or video.

Airspan is meeting that demand with a roadmap that provides superior technology solutions to ensure that the network development is one step ahead of the demands of the subscribers.

AS4020's baseline functionality will be supplemented by many new features in future releases.

3 Deployment, Configurations and Capacity

3.1 Airspan Network's Deployments

Airspan Network's AS4020 system is suitable for deployment in both developing and developed countries, in remote rural applications and large urban cities. Airspan has installed systems in more than 100 customer networks worldwide. For further details, please contact Airspan Marketing.

3.2 Type Approvals

In addition to being ETSI type approved and FCC qualified, Airspan Network's products have been approved in the following countries:

- **All European Union countries**
- China
- Czech Republic
- India
- Indonesia
- Philippines
- Poland
- Russia
- USA
- Brazil
- Sri Lanka

3.3 AS4020 Frequency Re-use

Due to the dynamic modulation feature, it is possible to deploy AS4020 in various network configurations to optimise system coverage, data throughput and frequency usage. AS4020's multiple access method (DS-CDMA) plus FEC makes it ideally suited to cellular networks offering contiguous service coverage. Frequency reuse patterns with N=1 for sectored of N=3 for omni cells are possible for contiguous coverage.

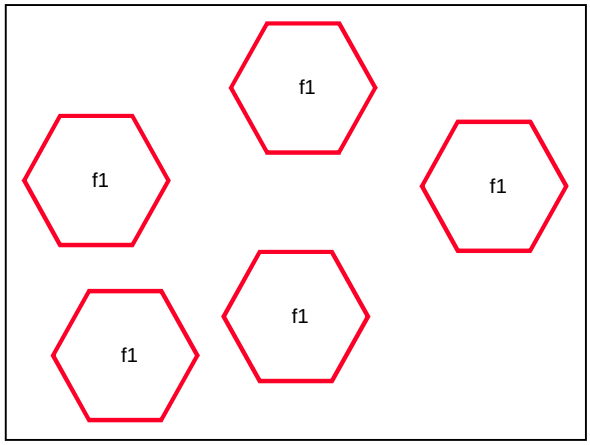


Figure 10 ***Island deployments***

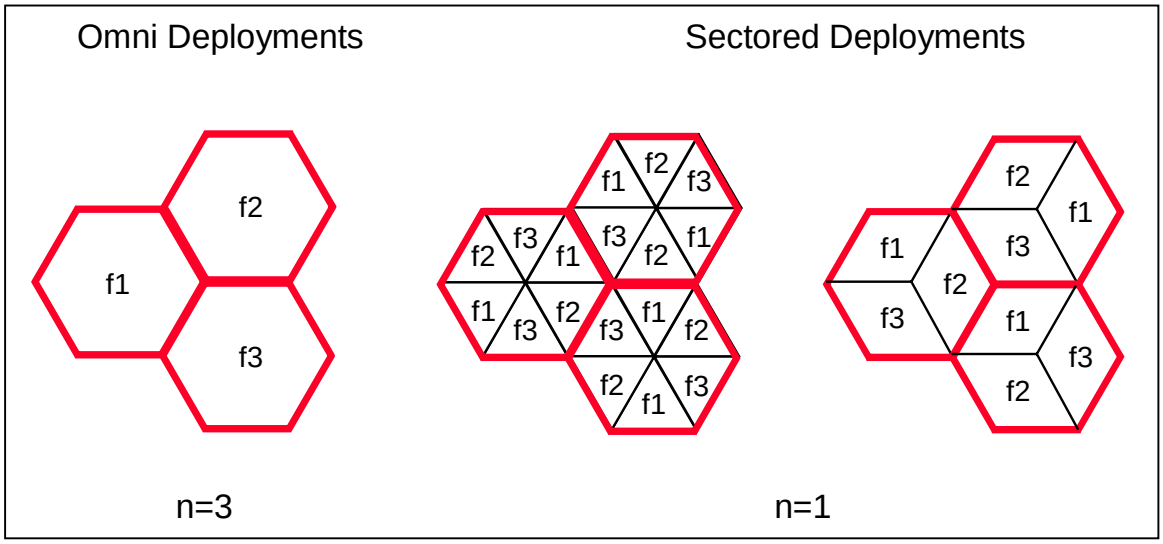


Figure 11 ***Cellular re-use patterns***

The actual capacity of any AS4020 network can only be determined after detailed study and propagation analysis (typically performed using Airspan Network's AS9020 AirPlan tool).

Sectored configurations of 30, 60, 90, 120 and 180 degrees with horizontal or vertical polarisation are supported.

AS4020 dynamically adapts to the prevailing co-channel interference environment, providing the maximum throughput possible at any one time.

4 System Features and Specifications

4.1 Conformance to Standards

The AS4020 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.

4.2 Frequency Ranges Supported

AS4020 operates in various frequency ranges within the PCS, ITU-R and ETSI 2GHz and 3GHz frequency ranges. A wide variety of channel plans have been developed (see Appendix) including:

- 1.8 - 1.9GHz, for deployments in the PCS A-D, B-E, C-F Bands 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
- 3.4 - 3.6GHz, in accordance with CEPT/ERC/Rec.14-03E (Turku 1996), with 100MHz duplex spacing

Considerable flexibility is built-in to the system to cater for the wide range of operator frequency allocations. This is achieved by the ability to soft-select (via custom configuration files) individual channel frequencies within each band.

The AS4020 system is designed to make optimum use of licensed spectrum, normally co-ordinated with other users by the licensing authority. Conformance with ETS 301 055 and 301 124 ensures co-existence with other radio systems.

4.3 Radio Link Budget

AS4020 is designed to 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. Shorter links operate in both Non and Near Line Of Sight (NLOS) conditions. High bit rate services and longer links LOS conditions. The system is dynamically able to adjust modulation schemes from QPSK to QAM16 or QAM64 on frame by frame basis to provide the most optimum throughput data service to a ST. As the modulation scheme is switched the effective receiver sensitivity changes. Therefore 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.

Typical radio performance parameters are given below (at 3.4-3.6 GHz):

Downlink				**Uplink**		
	QPSK	**QAM 16**	**QAM 64**		**QPSK**	**QAM 16**
CT transmit power/user	24	24	24	ST transmit power/user	21	20
CT feeder loss (dB)	2.5	2.5	2.5	ST connector loss (dB)	0.5	0.5
CT directional antenna gain (dBi)	17	17	17	ST directional antenna gain (dBi)	18.5	18.5
iST directional antenna gain (dBi)	18.5	18.5	18.5	CT directional antenna gain (dBi)	17	17
iST Connector Loss (dB)	0.5	0.5	0.5	CT feeder loss (dB)	2.5	2.5
Bit error rate	1.00E-07	1.00E-07	1.00E-07	Bit error rate	1.00E-07	1.00E-07
ST receiver sensitivity (dBm)	-103	-97	-86	ST receiver sensitivity (dBm)	-103	-97
Loss budget (dB)	159.5	153.5	142.5	**Loss budget (dB)**	156.5	149.5

Table 2 *Link Budget - 3 MHz Channels*

Methods of extending the system link budget are available by the use of higher gain ST antennas.

4.4 Speech Coding

AS4020 supports a range of circuit based coding schemes. 64kbit/s PCM to support full wireline equivalent services and 32kbit/s ADPCM for those applications where higher line density and quasi-wireline services are required and international standard (for delay) must be met.

4.5 System Security

ST authentication is carried out when an ST is powered up and attempts to contact the CT. Only STs pre-defined by the Netspan management system are allowed to join the CT. An alarm is raised if unknown STs attempt to join the CT.

The ST serial number is set at manufacture and is unique and unalterable, i.e. not held in a memory that could be altered or duplicated.

4.6 Subscriber Auto Connect

After an ST is powered up, it can be configured to go through a frequency scanning routine and automatically link to an RF Channel to which it has been pre-provisioned via AS8200 Netspan. This feature removes the need for an installer to program the ST with an appropriate RF Channel. The ST can be pre-configured such that it's scanning is restricted only to RF Channels used by the Network Operator, hence avoiding transmission in spectrum owned by another Network Operator.

4.7 System Capacity (AS4020)

4.7.1 Radio (RF) Channel IP Capacity

The capacity of a Radio Interface changes dynamically, depending on the modulation scheme in force. The table below illustrate the performance of CT in different states.

Each RF channel is split into 16 CDMA RW codes, each of which is simultaneously transmitted on the RF channel. The throughput of the RF channel corresponds to 15 RW codes. The throughput of an ST corresponds to 4 RW codes in the downlink and between 1 to 4 RW codes in the uplink, depending on how the ST is configured.

Description	Modulation	Chips/ Symbol	Code Rate	Bits/ Symbol	Frames/ Block	Block Data Rate (bps)	Net Rate per RW (bps)	Data Rate (Mb/s)		
								1RW	4RWs	15RWs
QAM64 (3/4)	QAM64	16	0.75	4.5	1	576000	568000	0.568	2.272	8.52
QAM16 (3/4)	QAM16	16	0.75	3	1	384000	376000	0.376	1.504	5.64
QAM16 (1/2)	QAM16	16	0.5	2	1	256000	248000	0.248	0.992	3.72
QPSK (3/4)	QPSK	16	0.75	1.5	1	192000	184000	0.184	0.736	2.76
QPSK (1/2)	QPSK	16	0.5	1	1	128000	120000	0.12	0.48	1.8

Table 3 ***CT Gross Air Interface Capacities***

4.7.2 Dynamic frequency allocation / System Fault Protection

Where multiple RF channels are supported from single CT equipment, STs have the ability to obtain service from all RF channels where an acceptable link budget exists. This supports:

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

At provisioning, a ST will be allocated an initial 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.

4.7.3 AS4020 System Capacity Limits

- Up to 480 Packet (or Voice and Packet) Subscriber Terminals per RF Channel
- Up to 4 RF channels per Central Terminal Rack (CT).
- Up to 12 sectors per cell site
- Up to 12 x RF channels (distributed amongst up to 12 CTs) can be supported per Access Concentrator (AC) shelf
- Each AC shelf can support up to 64x2Mbit/s E1 links, or up to 56 1.5 Mbit/s T1 links to a circuit switch Telephony Exchange.

Appendix A: Frequency Plans

Airspan Network's AS4020 system supports deployment within the PCS, ITU-R and ETSI 2GHz and 3GHz frequency bands.

A number of standard implementations have been developed and 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. ***Please contact Airspan Marketing for current availability and shipping information.***

Frequency Division Duplexing (FDD) is used with go-return spacing dependant on the channel plan used.

The RF channelisation is 3.0MHz or 3.5MHz and is arranged to give optimum usage of the band. The basic requirement for system operation is for a single RF channel.

In addition to the standard plans shown, customised channel plans can be deployed to cater for specific local conditions and regulatory constraints. These plans can be set-up by the operator and soft-downloaded to the equipment under NMS control.

Airspan is continually expanding the range of available frequency bands. For new frequency bands and plans, Airspan is able to develop specialised versions, and is always happy to discuss requirements.

Standard Channel Plan for 2.0 – 2.3 GHz, Plan 1

Channel	Uplink (MHz)	Downlink (MHz)
1	2029.75	2204.75
2	2033.25	2208.25
3	2036.75	2211.75
4	2040.25	2215.25
5	2043.75	2218.75
6	2047.25	2222.25
7	2050.75	2225.75
8	2054.25	2229.25
9	2057.75	2232.75
10	2061.25	2236.25
11	2064.75	2239.75
12	2068.25	2243.25

Standard Channel Plan for 2.0 – 2.3 GHz, Plan 2

Channel	Uplink (MHz)	Downlink (MHz)
1	2047.25	2222.25
2	2050.75	2225.75
3	2054.25	2229.25
4	2057.75	2232.75
5	2061.25	2236.25
6	2064.75	2239.75
7	2068.25	2243.25
8	2071.75	2246.75
9	2075.25	2250.25
10	2078.75	2253.75
11	2082.25	2257.25
12	2085.75	2260.75

Standard Channel Plan for 2.0 – 2.3 GHz, Plan 4

Channel	Uplink (MHz)	Downlink (MHz)
1	2045.50	2220.50
2	2049.00	2224.00
3	2052.50	2227.50
4	2056.00	2231.00
5	2059.50	2234.50
6	2063.00	2238.00
7	2066.50	2241.50
8	2070.00	2245.00
9	2073.50	2248.50
10	2077.00	2252.00
11	2080.50	2255.50
12	2084.00	2259.00

Standard Channel Plan for 2.0 – 2.3 GHz, Plan 5

Channel	Uplink (MHz)	Downlink (MHz)
1	2084.00	2268.00
2	2087.00	2271.00
3	2090.00	2274.00
4	2093.00	2277.00
5	2096.00	2280.00
6	2099.00	2283.00
7	2102.00	2286.00
8	2105.00	2289.00
9	2108.00	2292.00

Standard Channel Plan for 2.3 – 2.5 GHz, Plan 1

Channel	Uplink (MHz)	Downlink (MHz)
1	2308.00	2402.00
2	2312.00	2406.00
3	2316.00	2410.00
4	2320.00	2414.00
5	2324.00	2418.00
6	2328.00	2422.00
7	2332.00	2426.00
8	2336.00	2430.00
9	2340.00	2434.00
10	2344.00	2438.00
11	2348.00	2442.00
12	2352.00	2446.00

Standard Channel Plan for 3.4 – 3.6 GHz, Plan 1

Channel	Uplink (MHz)	Downlink (MHz)
1	3411.75	3511.75
2	3415.25	3515.25
3	3418.75	3518.75
4	3422.25	3522.25
5	3425.75	3525.75
6	3429.25	3529.25
7	3432.75	3532.75
8	3436.25	3536.25
9	3439.75	3539.75
10	3443.25	3543.25
11	3446.75	3546.75
12	3450.25	3550.25

Standard Channel Plan for 3.4 – 3.6 GHz, Plan 2

Channel	Uplink (MHz)	Downlink (MHz)
1	3453.75	3553.75
2	3457.25	3557.25
3	3460.75	3560.75
4	3464.25	3564.25
5	3467.75	3567.75
6	3471.25	3571.25
7	3474.75	3574.75
8	3478.25	3578.25
9	3481.75	3581.75
10	3485.25	3585.25
11	3488.75	3588.75
12	3492.25	3592.25

Standard Channel Plan for 3.4 – 3.6 GHz, Plan 3

Channel	Uplink (MHz)	Downlink (MHz)
1	3457.25	3557.25
2	3460.75	3560.75
3	3464.25	3564.25
4	3467.75	3567.75
5	3471.25	3571.25
6	3474.75	3574.75
7	3478.25	3578.25
8	3481.75	3581.75
9	3485.25	3585.25
10	3488.75	3588.75
11	3492.25	3592.25
12	3495.75	3595.75

Standard Channel Plan for 3.4 – 3.6 GHz, Plan 10

Channel	Uplink (MHz)	Downlink (MHz)
1	3452.00	3552.00
2	3455.50	3555.50
3	3459.00	3559.00
4	3462.50	3562.50
5	3466.00	3566.00
6	3469.50	3569.50
7	3473.00	3573.00

Standard Channel Plan for 3.4 – 3.6 GHz, Plan 12

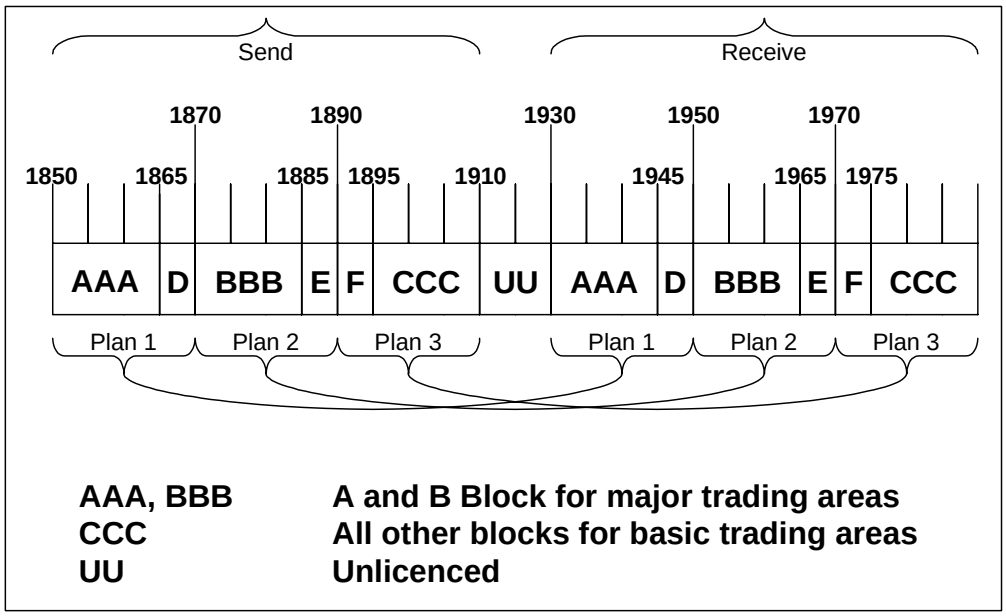
Channel	Uplink (MHz)	Downlink (MHz)
1	3413.00	3513.00
2	3416.50	3516.50
3	3420.00	3520.00
4	3423.50	3523.50
5	3427.00	3527.00
6	3430.50	3530.50
7	3434.00	3534.00
8	3437.50	3537.50
9	3441.00	3541.00
10	3444.50	3544.50
11	3448.00	3548.00

Standard Channel Plan for 3.4 – 3.6 GHz, Plan 13

Channel	Uplink (MHz)	Downlink (MHz)
1	3401.25	3501.25
2	2404.75	3504.75
3	3408.25	3508.25
4	3411.75	3511.75
5	3415.25	3515.25
6	3418.75	3518.75
7	3422.25	3522.25
8	3425.75	3525.75
9	3429.25	3529.25

Channel Plans for PCS Band

All PCS band plans have an 80MHz duplex spacing. The standard plans provide operators with considerable flexibility to optimize spectrum usage within the band allocation(s) that they have been given. As with the other frequency plans, individual operators may choose to soft-configure individual channels to operate within available licensed spectrum



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

Channel	Uplink (MHz)	Downlink (MHz)
1	1852.00	1932.00
2	1853.00	1933.00
3	1855.00	1935.00
4	1857.00	1937.00
5	1858.00	1938.00
6	1860.00	1940.00
7	1862.00	1942.00
8	1863.00	1943.00
9	1866.75	1946.75
10	1867.00	1947.00
11	1868.00	1948.00
12	1868.25	1948.25

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

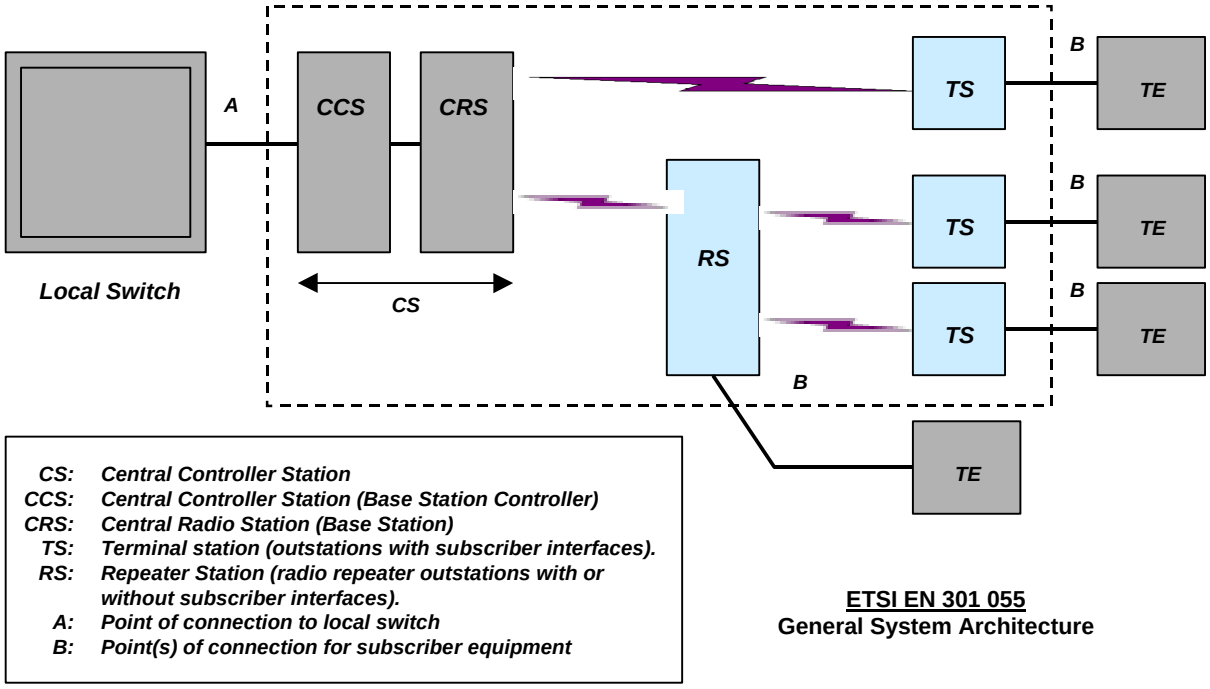
Channel	Uplink (MHz)	Downlink (MHz)
1	1872.00	1952.00
2	1873.00	1953.00
3	1875.00	1955.00
4	1877.00	1957.00
5	1878.00	1958.00
6	1880.00	1960.00
7	1882.00	1962.00
8	1883.00	1963.00
9	1886.75	1966.75
10	1887.00	1967.00
11	1888.00	1968.00
12	1888.25	1968.25

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

Channel	Uplink (MHz)	Downlink (MHz)
1	1891.75	1971.75
2	1892.00	1972.00
3	1893.00	1973.00
4	1893.25	1973.25
5	1897.00	1977.00
6	1898.00	1978.00
7	1900.00	1980.00
8	1902.00	1982.00
9	1903.00	1983.00
10	1905.00	1985.00
11	1907.00	1987.00
12	1908.00	1988.00

Appendix B: Compliance with standards and regulations

Airspan Network's AS4020 system architecture (and AS4000) 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.

AS4020 systems are designed to be fully compliant to the ETSI specifications for CDMA Point to Multipoint Digital Radio Systems EN 301 024 and 301 055, depending upon the channel plan adopted The following list provides a summary of the major telecoms and safety standards to which AS4020 complies :

Standard	Title
EN 301 055 1998	Transmission and Multiplexing (TM) Digital radio Relay Systems (DRRS) Direct Sequence Code Division Multiple Access (DS CDMA) Point to Multipoint DRRS in the band 1-3 GHz
EN 301 124 1998	Transmission and Multiplexing (TM);Digital Radio Relay Systems (DRRS);Direct Sequence Code Division Multiple Access (DS-CDMA) Point-to-Multipoint DRRS in frequency bands in the range 3 GHz to 11 GHz
EN 301 1245	Direct Sequence Code Division Multiple Access (DS-CDMA) point-to-multipoint DRRS in the range 3 to 11 GHz
ERC 13-01	Preferred channel arrangements for fixed services in the range 1-3 GHz
ERC 14-03	Harmonised radio frequency channel arrangements and block allocations for low and medium capacity systems in the band 3 400 MHz to 3 600 MHz
ETS 300 012	Integrated Services Digital Network (ISDN); Basic user-network interface; Layer 1 specification and test principles
ETS 300 019	Equipment Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment
ETS 300 166	Physical and electrical characteristics of hierarchical digital interfaces for equipment using the 2048kbit/s based plesiochronous or synchronous digital hierarchies
ETS 300 324 ITU-T G.964	Signalling Protocols and Switching (SPS); V interfaces at the digital Local Exchange (LE); V5.1 Interface for the support of Access Network (AN)
ETS 300 347 ITU-T G.965	Signalling Protocols and Switching (SPS); V interfaces at the digital Local Exchange (LE); V5.2 interface for the support of Access Network (AN)
ETS 300 385	Radio Equipment and Systems (RES); ElectroMagnetic Compatibility (EMC) standard for digital fixed radio links and ancillary equipment with data rates around 2 Mbit/s and above
ITU-R F.697	Error performance and availability objectives for the local-grade portion at each end of an ISDN connection utilising digital radio-relay systems
ITU-R F.701-1	Radio-frequency channel arrangements for analogue and digital point-to-multipoint radio systems operating in frequency bands in the range 1,427 to 2,690 GHz
ITU-R SM.329-7	Spurious emissions
ITU-T G.703	Physical / electrical characteristics of hierarchic digital interfaces
ITU-T G.711	Pulse code modulation (PCM) of voice frequencies
ITU-T G.726	32 kbit/s Adaptive Differential Pulse Code Modulation (ADPCM)".
ITU-T G.821	Error performance of an international digital connection operating at a bit rate below primary rate and forming part of an integrated services digital network
ITU-T G.823	Jitter performance
ITU-T G.964-5	See ETS 300 324 and ETS 300 347
ITU-T Q.543	Recommendation Q.543 (03/93) - Digital exchange performance design objectives
ITU-T R.20 and ITU-T V-series	Telegraph modem for subscriber lines
ITU-T Radio Regulation 831	ITU Radio Regulations Part 1

Appendix C: ISO9001 Certificate

UNDERWRITERS LABORATORIES INC.

CERTIFICATE OF REGISTRATION

ISO 9000

Airspan Communications Limited

Cambridge House
Oxford Road
Uxbridge
Middlesex, UB8 1UN, United Kingdom

with an off-site facility located at:

Airspan House
45 Riverside Way
Uxbridge
Middlesex, UB8 2YF, United Kingdom

Underwriters Laboratories Inc.® (UL) issues this certificate to the Firm named above, after assessing the Firm's quality system and finding it in compliance with

ISO 9001:1994

EN ISO 9001:1994; BS EN ISO 9001:1994; ANSI/ASQC Q9001:1994

for the following scope of registration

3663 (US) : Radio and Television Broadcasting and Communications Equipment

The system design, development, assembly, installation and repair of telecommunications equipment and systems.

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Renewal Date: December 10, 2003

S. Joe Bhatia
Executive Vice President and
Chief Operating Officer - International

UKAS
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UL REGISTERED FIRM

Appendix D: RF Planning

The planning of a fixed wireless network differs significantly from copper based access networks. The use of radio to replace copper in the traditional access network requires modifications to the deployment planning process with special emphasis on radio coverage aspects.

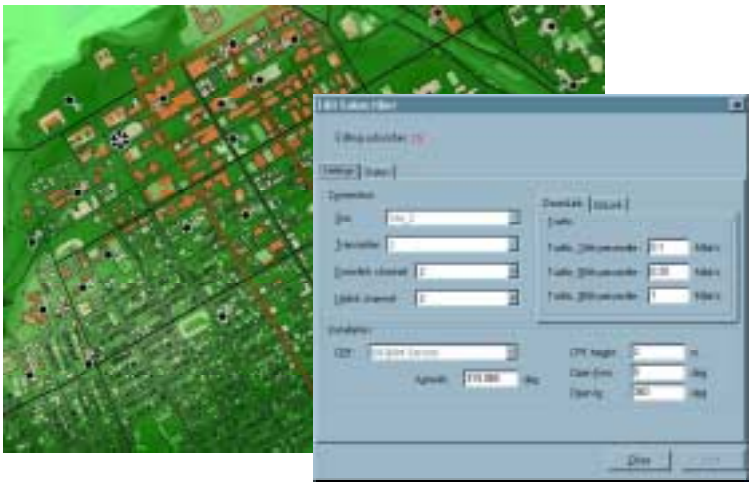
To assist operators in planning deployments for AS4000 and AS4020 networks, Airspan offers a companion product – AS9020 Airplan. AS9020 is a PC based tool that allows the user to predict the radio coverage from Central Terminal sites and supports all of the functionality required to plan the deployment of a network containing a mix of AS4000 and AS4020 equipment.

Service Penetration Predictions

The data rate and Quality of Service (QOS) to any subscriber in a network can be predicted using AS9020. A clear coverage map of the network is generated showing the level of service available in any particular subscriber location. This is derived from performing radio coverage analysis over digital elevation models of the area using proven radio propagation algorithms.

Once the Central Terminal sites have been determined, AS9020 can be used in conjunction with a radio measurement survey to compare actual and predicted coverage. This information can then be used to further enhance or modify the propagation prediction engine, and to take account of specific local variations in propagation conditions.

System Traffic Analysis



Subscriber databases can be set up in AS9020 to determine network capacity usage. Coverage analysis using link margins and interference levels will determine the best serving transmitter for a subscriber in a cellular network. Any change to the subscriber database are analysed and reflected in system capacity and QOS calculations.

Antenna Types

AS9020 can accommodate an unlimited number of antenna patterns for both CT and ST equipment. Customised antenna patterns can be loaded to suit deployment characteristics, providing increased flexibility to network optimisation.

GLOSSARY

AC	Access Concentrator
ADPCM	Adaptive Differential Pulse Code Modulation (A 32kbit/s speech CODEC)
BDM	Block Data Mode
BWA	Broadband Wireless Access
CAS	Channel Associated Signalling
CCS	Common Channel Signalling
CDMA	Code Division Multiple Access
CIR	Committed Information Rate
CLEC	Competitive Local Exchange Carrier
CODEC	Coder/Decoder
CT	Central Terminal
DA	Demand Assigned
DS-CDMA	Direct Sequence CDMA
DSL	Digital Subscriber Line
EMS	Element Management System
Erl	Erlang
ETSI	European Telecommunications Standards Institute
FCAPS	Fault, Configuration, Accounting, Performance, Security
FCC	Federal Communications Commission
FDD	Frequency Division Duplex
FEC	Forward Error Correction
GoS	Grade of Service
ILEC	Incumbent Local Exchange Carrier
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ISP	Internet Service Provider
ITU	International Telecommunications Union
Km	Kilometre
LAC	Link Acquisition Channel
LAN	Local Area Network
LOS	Line of Sight
MIR	Maximum Information Rate
NLOS	Near Line of Sight
OAM	Operations and Management
ODU	Outdoor Unit
PC	Personal Computer
PCS	Personal Communications System
PIR	Peak Information Rate
POTS	Plain Old Telephone Service
PSTN	Public Switched Telephone Network
PSU	Power Supply Unit
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
QPSK	Quadrature Phase Shift Keying
RF	Radio Frequency
RW	Rademacher Walsh (CDMA Code)
SIU	Service Interface Unit
SME	Small to Medium Enterprise
SOHO	Small Office / Home Office
ST	Subscriber Terminal
VF	Voice Frequency
VLAN	Virtual LAN
VPN	Virtual Private Network