SILVERNET

PICO 95

MICRO2 95

LITE 95

MAX 95

How it works

Version 2.0 (01/06/2017)

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Introduction

The use of high speed networks has exploded over the past few decades. Every day we use these communications networks as common place tools for conducting business, delivering education, accessing government, securing our streets and bridging "the digital divide".

One network technology commonly being used today for such networks is wireless. The use of radio has meant that networks can be implemented faster and potentially much cheaper than via traditional means such as cable.

As a designer/manufacturer of wireless transmission solutions, SilverNet is at the forefront of extending wireless networking possibilities every day. It is achieving this through its ongoing interaction with partners and end users worldwide who challenge us daily to innovate, imagine and to deliver best in class wireless capability.

The goal for this document is to provide SilverNet's partner community with basic, practical reference information about the wireless world and SilverNet's technology solutions as well as to set out how SilverNet believes it can best support your efforts as our partners to win wireless networking opportunities.

Unique in our industry; this document was developed to share our knowledge and experiences with wireless networking so as to help you use SilverNet's technology to its optimal. The SilverNet team realises that wireless can often appear to be an ever increasingly complex and overwhelming domain. With this in mind, SilverNet has tried to write this document in an easy, not overtly technical manner, based on real world experience so that you and others in your partner organisation (at whatever level of experience or understanding) can better grasp how the technology works, where it is typically used and how you can best access SilverNet's advantage.

Wireless networking is much like playing "join the dots". Your end goal as a wireless networker is to connect people and locations together. By promoting a spirit of cooperation between SilverNet and its partners, SilverNet expects a win-win-win scenario to prevail for all. SilverNet wins market share, partners win extra sales volume and end-users win advantage for their businesses through access to a variety of the highest-quality wireless applications.

We hope this document will allow us join some dots together to build out stronger, commercially savvy partnerships.

What is a wireless Network?

A wireless local-area network (LAN) uses radio waves to connect devices such as mobile phones to the Internet and to your business network and its applications. When you connect your phone to a WiFi hotspot at a cafe, hotel, airport lounge, or other public place, you're connecting to that business's wireless network.

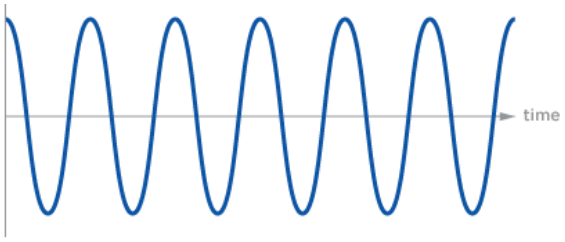
When SilverNet talks about Wireless networking, it talks about a breed of technology that communicates data between points (fixed or mobile) without the need for wires. The data can be voice, or video or any other kind of computer information (called IP packets).

Basic radio theory

This section is by no means in depth or complete. Unlike wireless systems of the past, current wireless technology is designed for people building networks, not radio engineers!

Wireless (radio) signals travel through mediums such as the air and copper wire. Radio signals are electrical signals. When an electric current travels through a piece of wire, it emits a wave in the air around it. By using a proper combination of wire types, shapes and lengths (such as an antenna), it is possible to force an electrical signal to travel through the air without any wires. Radio **propagation** is a term used to explain how radio waves behave when they are transmitted, or are propagated from one point to another.

If you can visualise a radio signal as a wave, they go up and down at varying speeds. This is called the **frequency.** Antenna design is particular to the frequency and beam propagation required.



In sending an electrical signal out in to the air, the signal must be made to behave in a way that can transfer information. This is called **modulation**.

A SilverNet wireless radio takes information from your computer and modulates it. It creates an electrical signal that is sent along a wire, to an antenna.

As the radio signal travels through the air it passes through various objects (such as oxygen, birds, insects, trees, houses, etc.).

All of these things absorb the radio signal. This is called **loss**. The amount of loss that happens because of a signal travelling through the air is called '**free space loss'**. Other objects such as buildings or trees also cause loss.

Consequently, you ideally want to send radio signals through air and air only. **Line of Sight** is NOT what you can see; it is the result of the calculation of Free Space taking into account the size of the Fresnel Zone and the 60% rule.

Bringing all of these factors together makes it possible to tell how far a radio signal will travel and get an idea of how much information can be transmitted based on:

- The amount of power the antenna is transmitting into the air.
- The distance between the transmitting and receiving sides.
- How much radio signal the receiving radio needs.
- What types of obstructions are in the way?

Radio Signal

A radio needs to be able to hear a radio signal at a certain level. As the radio signal travels through the air, it weakens (much like shouting at someone from a mile away). '**Receive Sensitivity'** is defined as the level of the Rx at which a usable signal is detected. It is not minimum and will alter constantly.

Radios are usually rated in dBm or decibels over a milliwatt. Note that this is the same unit as the radio's transmission power. When a radio signal leaves the transmitting antenna the dB will be a high number (for example: 25 dB). As it travels through the air, it loses strength and will drop to a negative number. This is why the amount of power a receiver needs is often rated as -X (where X can be any number) dB.

The use of negative numbers can be confusing at first. Just remember, 20 is higher than 0, and -20 is lower than 0. Thus if you can achieve a signal level of -60 dB and your radio needs -80, you have 20 dB of extra signal to accommodate interference and other issues. A decibel is a ratio for managing large numbers.

How far can it go?

Now that you know how much power you can put out, and how much you need, you can readily work out how much radio signal will be available at the receiving end. The way this is worked out is to determine how much **loss** is present between the two radios.

Remember, as a radio signal travels through the air it loses power. This is called '**Free Space Loss'**, or "the amount of signal lost while travelling through free space".

Although calculations can be done quickly by hand, SilverNet's range calculator tools can be used to save time and help visualise how these numbers fit together.

How information becomes wireless

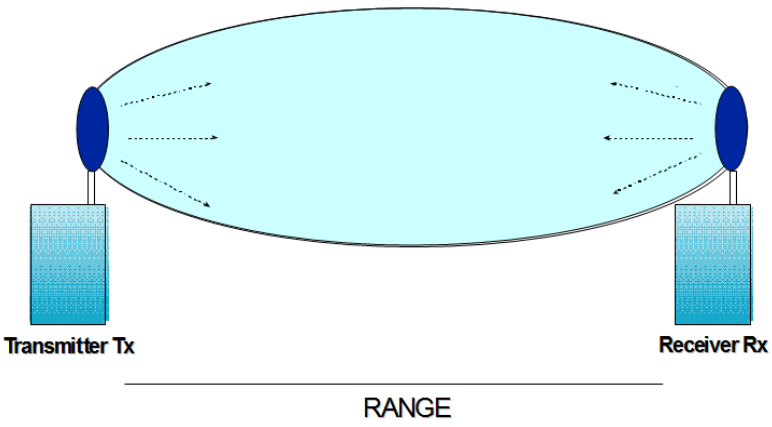
In plain English, a computer system is connected to a SilverNet wireless device using an Ethernet cable. Information sent from the computer (or other computers on the same Ethernet network) are delivered to a SilverNet wireless device:

- A SilverNet transmitter sends radio signals with information to an antenna.
- The antenna takes the radio signals and directs them into the air and directs the radio signal toward a specific physical location.
- A SilverNet receiver hears the radio signals by way of its own antenna, and converts them back into a format a computer on the other end can use.

Once the radio signal leaves the transmitter's antenna, it travels through the air and is picked up by receiving antennas. As the signal travels through the air, it loses its strength, eventually losing enough power that it cannot be accurately received. The objective is to always use an appropriate combination of antennas and transmitters to deliver enough radio signal that a reliable wireless link is maintained over the system.

In SilverNet speak our wireless bridges allow digital information (data, voice and video) to be transferred from one point to another (or multiple points) without a wire connection between them. To do this, we employ radio technology, which encrypts and splits the data into a stream of radio signals, which are then sent from one antenna (the AP) to another (the station). The station then decrypts the information and feeds it back into the network. Just as with wired networks, the data exchange goes both ways.

So a simple SilverNet point-to-point link would look like this:



What are the legal implications of using wireless?

SilverNet's wireless radios operate in the 5Ghz frequency band.

The UK has specific regulations as to the operating frequencies at which you can use your 5GHz Wireless Networking equipment. There are 3 bands called Band A, B and C which operate on the frequencies shown below:

Channel	Frequency	Band	Maximum EIRP
36	5.180	A	200mW
40	5.200	A	200mW
44	5.220	A	200mW
48	5.240	A	200mW
52	5.260	A	200mW
56	5.280	A	200mW
60	5.300	A	200mW
64	5.320	A	200mW
100	5.500	B	1W
104	5.520	B	1W
108	5.540	B	1W
112	5.560	B	1W
116	5.580	B	1W
120	5.600	B	1W
124	5.620	B	1W
128	5.640	B	1W
132	5.660	B	1W
136	5.680	B	1W
140	5.700	B	1W
149	5.745	C	4W
153	5.765	C	4W
157	5.785	C	4W
161	5.805	C	4W

Band A (5.150-5.350GHz) – License free operation

All devices must comply with ERC Decision 99(23) and IR 2006 which includes TPC (Transmit Power Control) and DFS (Dynamic Frequency Selection), be part of a mobile/nomadic wireless network (i.e. WLAN applications), have a maximum EIRP of 0.2W (200mW) and must be for indoor use only.

Band B (5.470-5.725GHz) – License free operation

All devices must comply with ERC Decision 99(23) and IR 2006 which includes TPC (Transmit Power Control) and DFS (Dynamic Frequency Selection), have a maximum EIRP of 1W with indoor and outdoor use being permitted.

Band C (5.725-5.850GHz) – License required for operation

All devices must comply with IR 2007, have a maximum EIRP of 4W with a PSD not exceeding 23dBm/MHz, have TPC (Transmit Power Control) and DFS (Dynamic Frequency Selection) and is only to be used in Fixed Service Operations applications (i.e. Point-to-Point links between 2 stationary locations).

Note: The frequency ranges and bands that are regulated in the UK are different to those found in the USA. Also, maximum output power of American equipment is 4 times less than that of the regulations in the UK. Therefore, for legality issues and optimum 5GHz Wireless Networking performance, it is critical that you do not purchase products intended for the US market for use within the UK.

Dynamic Frequency Selection (DFS) is the process of detecting radar signals that must be protected against 802.11a interference, and upon detection switching the 802.11a operating frequency to one that is not interfering with the radar systems.

Transmit Power Control (TPC) is used to adapt the transmission power based on regulatory requirements and range information.

In the UK, all radios operate under the control of Ofcom. Radio use in the 2.4 & 5GHz bands are deemed to be Licence Exempt with the exception of BAND C. Band C (5.725 to 5.825GHz) requires registration with Ofcom under a light licensing scheme. While this band is still effectively licence exempt, Ofcom wants to keep a register of all FWA links and charges a small fee. Any user wishing to set up an outdoor link for FWA needs to apply to Ofcom for a site license; the licence is not hard to obtain and is only £50 which includes registration of up to 50 terminals. For every terminal beyond 50 you should add £1 to the cost of your licence.

Further information on the legal implications of Band C usage can be found on the Ofcom.

Is there any health concerns using Wireless?

There is no known, industry sponsored scientific evidence which proves that Wireless technology poses a risk to human health. However, many independent research findings have linked health risks with very high intensity radio systems (not what SilverNet produces). License-exempt bands, in which all SilverNet products operate, use very low amounts of power and are considered safe for use near humans. Licensed radio systems pose a significantly higher risk to human health than license-exempt systems because they are permitted to use higher amounts of power. Although there are risks associated with wireless technology, it is generally safe for public use.

So why use wireless over wired technology?

There are numerous benefits some of which are:

- **Lower cost of ownership** – no expensive trenches to dig, cable to lay, walls to be drilled or disruption to existing systems and people.

- **No transmission cost** – unlike fibre there are no leased line costs to pay. SilverNet's wireless bridges operate over allocated unlicensed frequencies, so there is no ongoing transmission costs after the hardware has been purchased.

- **Much faster deployment** – no cables have to be laid or routed & connections can be made in a fraction of the time of traditional options

- **High performance**- SilverNet's wireless bridges now deliver in excess of 500Mbps, more than enough for CCTV, VoIP and other bandwidth-hungry applications.

- **High security** - SilverNet's wireless bridges use 128 bit AES encryption, TKIP and our own advanced data compression technology, rendering any signals picked up by 'sniffer' devices useless.

Wireless standards explained

The original wireless networking standard was finalised in 1997. Called IEEE 802.11, this standard meant that manufacturers could work to a code to ensure wireless devices from other companies would be compatible with each other. The following is a brief overview of the different variants under the standard.

802.11bg

In July 1999, the IEEE expanded on the original 802.11 standard, creating the 802.11b specification. 802.11b supports bandwidth up to 11Mbps, compared to the lower 2Mbps 802.11 standard.

802.11b works by using the same license-exempt frequency (2.4 GHz) as the original 802.11 standard, however, as it is unregulated, 802.11b devices can suffer interference from microwave ovens, cordless phones, and other appliances using the same 2.4 GHz range.

In 2002 Wireless LAN devices which supported 802.11g came onto the market. Essentially, this standard's aim was to remove the confusion over the different standards and combine the best of both. The resulting 802.11g standard supports bandwidth up to 54Mbps using the same 2.4Ghz frequency.

- **Pros** - low cost, good signal range and strength
- **Cons** - slow speed, especially if you intend to have simultaneous connections, possible interference with other radio wave devices

802.11a

At the same time IEEE created a second extension to the original 802.11 standard called 802.11a.

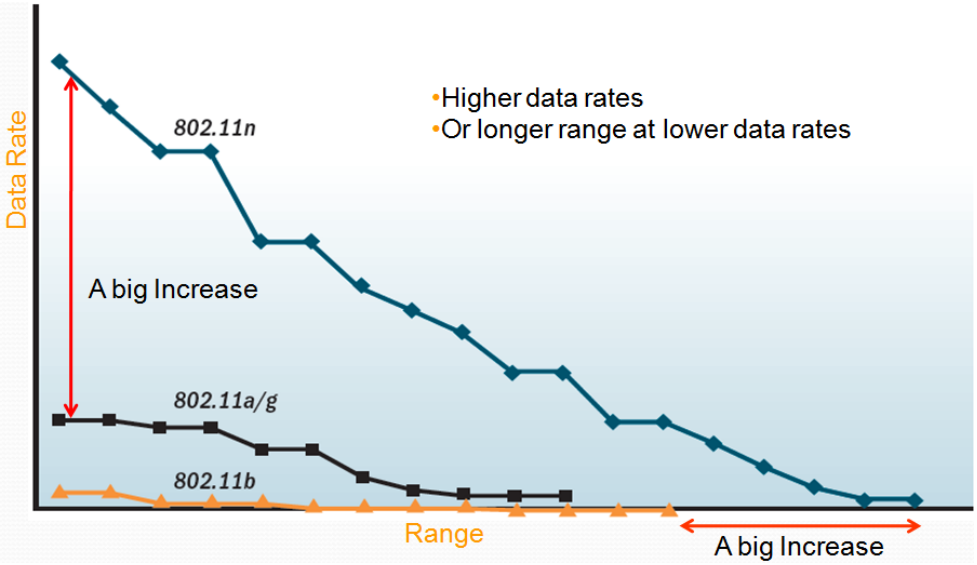
802.11a was aimed more at the business market, as it had higher manufacturer costs over the 802.11b devices. 802.11a can support bandwidth up to 54Mbps and uses a regulated range of 5 GHz frequencies, compared to the unregulated 2.4GHz range of 802.11b. 802.11a uses a higher frequency (5Ghz) and so signals can suffer problems going through walls, in some cases people have found a better signal is achieved connecting from above or below as these have lower resistance for the signal to the solid walls.

- **Pros** - fast maximum speed, capable of simultaneous connections, regulated frequencies prevent signal interference from other radio devices
- **Cons** - highest cost and shorter ranges

802.11n

In 2009 802.11n came onto the market. Essentially, this standard's aim was to increase the end users available bandwidth to that of wired speeds. The resulting 802.11n standard supports bandwidth up to 300Mbps and uses the 2.4GHz (nbg) or 5GHz (na) frequency, providing far greater signal range and performance. 802.11n devices are backwards compatible to connect to legacy equipment.

- **Pros** - Faster speeds and support for simultaneous connections, good signal range. Duplex Transmission.
- **Cons** - Can cost more than previous standards.



802.11ac

The newest standard called 802.11ac utilizes dual band wireless technology, supporting simultaneous connections on both the 2.4GHz and 5GHz Wi-Fi bands. 802.11ac offers backward compatibility to 802.11a/b/g/n and bandwidth rates up to 1300Mbps on the 5GHz band plus up to 450Mbps on 2.4 GHz.

- **Pros**– Faster speeds when compared to previous technology, support for simultaneous connections, improved range.
- **Cons**–Higher cost and still prone to interference on the 2.4GHz frequency

Specifying Wireless

By surveying on a project-by-project basis, you can better understand how a particular environment will affect the performance of a wireless signal, with the added bonus of gaining experience without annoying your customers!

The site survey

The first thing to do when setting up a wireless network is to conduct a site survey. The survey will help you understand the coverage area for the network and identify the types of equipment needed to successfully build a wireless network. You don't need to spend a lot of money on an expensive survey kit. The purpose of surveying is to get an idea for how well a wireless signal will travel.

A basic survey kit might include:

1. A SilverNet radio link
2. A couple of laptops
3. A spectrum analyser to assess local radio noise
4. A GPS unit to determine your latitude, longitude and estimated elevation
5. A compass and digital camera
6. Appropriate mounting equipment for the antenna, such as a tripod and metal pole.
7. A pair of walkie-talkies

Is a site survey always necessary?

To establish the true site conditions and best success of the link, it is always recommended that a full site survey take place. Should a full site survey be performed, access to all of the available radio mounting points or towers that may be used will be required. Very often, the use of cherry pickers to complete the tests at the correct height is beneficial.

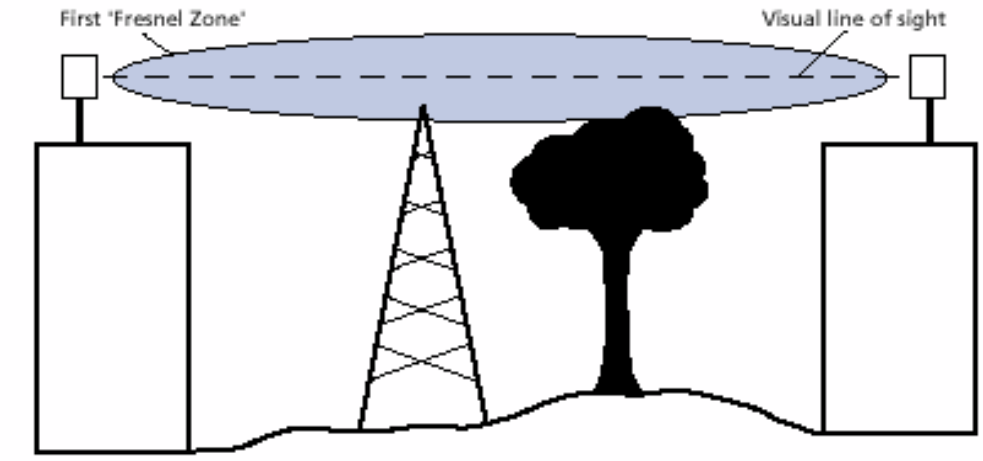
Key things to look for and do when on site

1. The Site's latitude, longitude and if possible, elevation (use a GPS)
2. The received signal readings and the noise levels at all locations.
3. Whether power is available.
4. Whether the site is readily accessible (for maintenance).
5. Visibility from the site (what can it see?).
6. Taking pictures of the site and from each place where a SilverNet wireless device could be mounted is always very useful.
7. Where antennas may be placed, and how they can be mounted

Line of sight

SilverNet's wireless bridges can work off reflected signals at short ranges where near or in some cases no line of sight exists, however SilverNet's radios perform best where a clear RF Line of Sight exists between antennas.

The radio waves between transmitter and receiver form a rugby ball-shaped area, called the **Fresnel Zone.** The zone is widest at the mid-point between the two antennas. Any obstructions that could break into this zone should be avoided, especially over long range.



Is the site suitable for wireless?

When assessing suitability of a site, always take note of the following:

- **Tall trees** (which may continue to grow in season and interfere with RF line of sight by absorbing radio signals)
- **Potential for further installations** between antennas e.g. chimneys, towers etc in the near future
- **The presence of large lakes or rivers**, which can reflect the signals and interfere with range and data throughput

The survey method

The wireless survey method below is a quick guide on how to conduct a wireless survey. Ideally you will use a cherry picker for each end of the link Or high building roofs.

Location A

Fit the equipment to a tripod and stand the tripod in the bucket of the cherry picker and raise to the height which will be the approximate installation height. Mark the data cable at the approximate lengths (6, 8, and 10 Metres for example) so you know what the antenna height is when testing.
Run the data cable down from the bucket of the picker to the ground and into the cab of the cherry picker where a 12vdc socket will power an inverter which will power the radio and laptop.
Set the alignment via compass or GPS for the antenna to pick up the most radios within its coverage (multipoint) or for the correct point to point location.

Location B

Set this up as above

Data test

Once the link is established run a data test for up to 10 minutes to ensure the link quality is adequate. Write down the results, take pictures if needed.
A little alignment may be needed to get the link signals to optimum.

What bandwidth does the user require?

The amount of bandwidth needed will govern the range that can be achieved. The longer the link is, the lower the bandwidth will be at the receiving end.

What range is required?

As above, range will govern the bandwidth that can be achieved. The longer the range, the less bandwidth can be expected.

What should the Antenna height be?

Generally, the higher the antenna can be mounted the better, but there may be height restrictions in some cases, which need to be taken into account.

What types of link may work best?

There are two main type of radio link - **point to point** or **point to multipoint**. The optimal solution will always depend on a combination of site configuration and customer requirement.

For point to point, SilverNet would normally recommend radios with integrated antennas such as the **PICO**, **MICRO**, **LITE** or **MAX** links

For point to multipoint SilverNet would normally recommend:

The **BASE 500** with sector antenna as the base site and **MICRO** or **LITE** at the remote sites.

What frequency is required?

SilverNet's wireless systems operate in the license-exempt 2.4 and 5GHz frequency bands. With the deregulation of 5GHz now complete in most countries, SilverNet recommends 5GHz is specified as it delivers longer distance and larger bandwidths.

What is the usual distance between network connection and radio?

SilverNet's radio family use Power over Ethernet (PoE) injectors, which provide power and data to the radio and the link to the network. The maximum distance between a radio unit, PoE and the network connection is 100metres.

SilverNet can supply cables in 10, 20, 50 and 90 metre lengths. Joining cables is never recommended.

Line of Sight (LOS) and Near Line of Sight (NLOS)

All radios working in either the 2.4GHz or 5GHz frequencies are Microwave. The characteristics of these frequencies are that they travel in a straight line (at the speed of light).

Line of sight is the characteristic of radio beam travel but is complicated because the beam has three dimensional properties. To determine true line of sight involves a calculation and ground profiles. However, as a good indicator, if the opposite end can be seen with minimal obstruction (buildings) then there is affair chance it will work.

Near line of Sight, indicates low range and along urban streets. It does not mean around hills!! Typical range would be less than ½ mile.

Connectivity

SilverNet radios operate at Layer 2 of the ISO/OSI (Open System Interconnection) seven layer model. Layer 2 is the Data Link layer and devices operate as LAN Bridges.
All SilverNet radios have an IP67 RJ45 CAT5 connector. All data is IP (Ethernet). Any other data formats will require conversion at either end. For example, if someone has a serial input (RS232 or similar), an RS232 to Ethernet converter will be required at each end. The Ethernet port is 10/100/1000 auto sensing (10BASET or 100BASET or 1000BASET). Data and power is fed from a power/data injector operating at the 802.3af standard, this means a single cable can be used. The PoE injector is an indoor unit.

Typical Wireless applications

A common requirement that SilverNet equipment is used for is point to point (PTP) wireless data links where the objective is to connect two or more networks together via a wireless bridge in preference to using cables.

Point to Point links

SilverNet's wireless bridges can be specified for this purpose according to the distance to be bridged:

PICO up to 1KM - MICRO up to 2KM - LITE up to 6 KM – MAX up to 60 KM

Point to Multipoint Links

For Point to multi point (PTMP) applications, a single radio unit can be configured as the AP, with other radios linked to it as stations. There are limits to the number of stations that connect to an AP based on divided bandwidth and processing of the number of remote station there are on the network.

We would recommend no more than 32 stations to one AP.

Using antennas

A system's use will determine the best type of antenna to use. The following is a rough guide only and ranges are subject to line of sight conditions and bandwidth required:

Omni	Sector	Directional
		
Mostly used for short range Multipoint connections	Used for Medium range Multipoint connections	Used for Point to point over longer ranges or the Station in a multipoint system

Wireless CCTV

SilverNet's systems are ideal for wireless CCTV applications up to 60KM. IP-enabled cameras can be linked directly or traditional analogue CCTV cameras can be linked using an IP encoder and decoder at each end. With this type of architecture reliable city wide networks can be quickly created and expanded with minimal hardware.

Mobile deployments

SilverNet's wireless systems can be overtly or covertly deployed in a fraction of the time of hardwired systems and linked back to a mobile control centre, providing greater flexibility and responsiveness.

Wide area coverage – urban and rural

SilverNet radios provide near line of sight (NLOS) performance up to 60 km, allowing them overcome tall buildings and trees, placing CCTV where it would often be unviable for hardwired systems.

Fast, Cost effective CCTV extensions

When additional network coverage is required, existing CCTV infrastructure can be quickly and very cost effectively extended using SilverNet wireless.

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