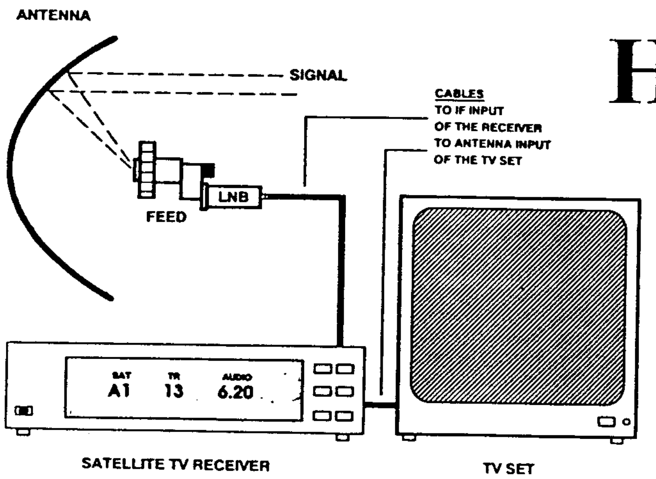
TECH BULLETIN 9404(t)

DIRECT TO HOME:



Home Satellite Dish System

INSTALLATION TECHNIQUES

-ABOUT TECH BULLETIN-

Tech Bulletin is produced and distributed by technology author and researcher Robert B. Cooper five (5) times per year. **Tech Bulletin** selects a single 'topic' for discussion in each issue to provide readers with a set of reference materials for work in this field.

In 1993, Tech Bulletin's five issues covered: **(9301)** Co-Channel television interference solutions, **(9302)** VHF fringe area reception and antenna practices, **(9303)** UHF fringe area reception and antenna practices, **(9304)** Eliminating man-made noise sources from VHF-UHF reception, (9305) Cable TV Basics: Part One of Two. Copies of these single issues are available at $15 each or (NZ) $60 for all five 1993 issues.

In 1994 **Tech Bulletin** issues (will) deal with **(9401T)** Cable TV Basics: Part Two, (9402T) MATV/Master Antenna system planning, (9403T) VHF/UHF Receiving Antenna 'Design Tricks', (9404T) C and Ku band(s) Home Satellite System Installations (this issue), and, (9405T) Commercial satellite installations in motels, clubs (available *October 17*).

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DTH
DIRECT TO HOME
SATELLITE RECEIVING SYSTEMS

TECH BULLETIN 9404(T)-

Everything we know about the status of telecasting in New Zealand points at the inescapable conclusion: New Zealand will become a nation served by domestic direct-to-home (DTH) satellite broadcasting by this time in 1995; perhaps sooner. Coming with the now familiar roof line 'bulges' that satellite service inaugurates will be several important, new to New Zealand electronic shoppe pieces of hardware and business techniques. The new hardware (electronics and antennas) will mean new business opportunities for existing firms as well as people who may not presently be involved in the consumer electronics industry. And the new 'software' business, the programming from the satellites, will cause a number of ripples in the established distribution pattern for television viewing material in New Zealand.

THE SOFTWARE ASPECTS FIRST-

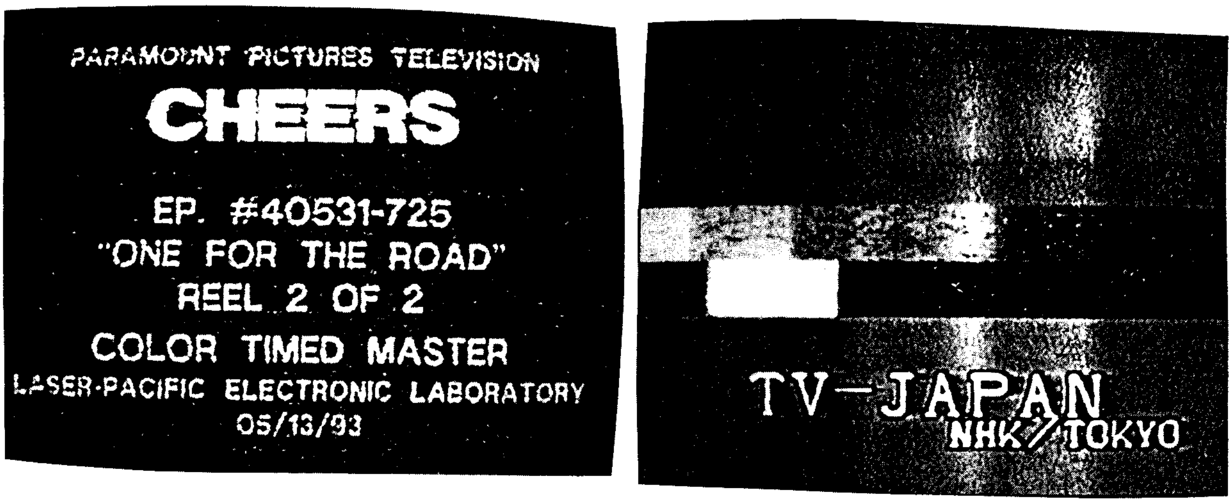
Paying for television programming is not a new concept in New Zealand; SKY Network presently reaches into nearly 22% of all New Zealand homes within range of its existing transmitters and their monthly charge for three channels of programming has conditioned the viewing audience to the concept that not all television is free of a reception charge.

In the satellite television world, there are four general categories of television programming. Two of these 'formats' are typically encoded such that viewers receive the programming only after agreeing to pay a (monthly) fee to access the programming channel.

1) Fortuitous reception: This is typically 'directed transmissions' of a non-scheduled nature; a one-off sporting event being relayed by satellite from perhaps Australia to America, live coverage of a news event with the transmission intended for a major news centre someplace in the world, or the satellite relay of a commercially sponsored (advertising supported) programme being delivered from point 'A' (such as Los Angeles) to point 'B' (such as Sydney). This is the category of programming presently found on Intelsat C-band transmissions received in New Zealand; and there is less and less of it each year. It is not intended for 'DTH' viewers, the transmission schedule suits the people it is intended to serve, and an individual home with a satellite dish does not qualify as an intended viewer.

2) Commercially sponsored transmissions. This is a service that encourages DTH viewers, counts the viewers in its own audience measurement system, and sells advertising to sponsors based upon DTH (plus perhaps cable, SMATV) 'homes'. One variation of this is the religion rooted or 'family values' service which may carry limited direct advertising but which 'sells a message' with its programming content. It will be many years before we have any of the first type; there could well be a religion based service available here by late-1994.

Neither fortuitous nor commercially sponsored programming is encoded; the viewer needs a satellite dish 'system' but no encoding equipment. No fees are charged for these channels.



FORTUITOUS: Final episode of 'CHEERS' appeared on satellite for world-wide distribution months before it aired in New Zealand (left); NHK (Japan) feeds are found daily on several C band satellites (right).

3) <u>'Entertainment channels' with advertising</u>. Most of the services available world-wide fall into this category. CNN, ESPN which are base services for SKY are in this category; as will be the Cartoon Network, TNT Television, Discovery Asia, MTV (Music Television) and others. These channels are encoded (scrambled) and require viewers to pay a fee (monthly, annually) for access. We'll discuss encoding separately here.

4) <u>Premium channels without advertising</u>. These are typically the movie services (Showtime, HBO and others), and, the 'adult' channels. These channels, too, are encoded and require viewer fee payment for accessing.

A 'basic' satellite terminal includes the dish and its mount, the dish-electronics (called LNB), the cable that connects the dish electronics to the inside electronics, and the actual satellite 'receiver'. This is all the viewer needs (other than a television set!) to enjoy fortuitous and commercially sponsored programme channels.

However, to receive encoded transmissions the viewer also requires a decoder. Originally decoders were much like the SKY units; stand-alone, separate pieces of electronics which inserted into the line after the satellite 'receiver' but ahead of the TV set. Gradually the encoding functions have migrated to the satellite receiver, typically as an IRD (integrated receiver descrambler) which is sold as a module that fits into a 'pocket' or nest in the receiver. The IRD takes its operating power from the receiver supply, and has multiple mates-with connectors that plug it into the appropriate receiver points to allow the receiver plus IRD to function as a working 'team'. We'll return to this important point.

In many portions of the world the firm that sells, installs and maintains home satellite systems is also involved as an agent for the 'software' or programming channels. The theory is that the average consumer requires some initial instruction on coping with the special receiver controls dealing with encoded programming, and it is less expensive to bring the satellite dealer into the 'sales network' for the software (encoded programming) than it is to have a special crew that performs this function exclusively. As 'agents' for the software services, satellite hardware dealers earn a commission for the initial 'sale' of a software (programming) service, and may also receive a (small) ongoing commission for maintaining the viewer-account on behalf of the programmer.

If this is the system that evolves in New Zealand, everything about your present TV sales and service business will change quite dramatically. Here's why.

When you walk into a video (movie) rental shoppe today, you are surrounded by posters of movie stars, cardboard cut-outs depicting movie action, and in the more upbeat shoppes surrounded by monitors all showing recent release promotions for (rental) movies. Compare that with your own present shoppe where you might have one or TV sets running with TV1 or TV3 on display.

A satellite sales shoppe becomes more like the former than the latter; the programming services appointing you as their agent will ship you posters, cardboard cut-outs, display materials and reams of handout literature. They want your shoppe to have the excitement and flavour of a 'show-business' centre. They, after all, are selling software, delivered by satellite. To attract customers the programmers use the abundantly available graphic materials and skills of the movie and entertainment industry to entice the customer to subscribe to their service. You, as their agent, are expected to dress, act and be a part of the "entertainment industry" and presentation, to them, is everything.

Act? This is an intensely promotion oriented business. And it goes much deeper than banners and posters. As an 'agent' for a service (we'll call it SKY Satellite Direct or SSD for convenience here) you will be assigned a 'territory' or region, although perhaps not on an exclusive basis. Within that territory, you will expected to 'show off' the service at public events, to act as a sampler of public opinion concerning the programming of the service(s), to defend the service when splinter groups within your community find something to beef about with the service.

You will also be expected to have (or grow into, rapidly) all of the necessary test, installation and display equipment the job requires. That could even mean that you have one (or a fleet of) trailer mounted satellite dish antennas which can be pulled to a location (home, tavern, school) for an overnight or weekend 'show and tell' display of the service. The programmers know from experience that the best selling tool for their service is for people to have it in their home (tavern, motel) for a display period; say a weekend. To accomplish this with a minimum of travel and set-up time, most dealers equip an appropriate sized trailer (with Ku band antennas the trailer can be just a couple of metres square, like a garden style trailer people use to haul rubbish to the tip) with a satellite antenna. Trailers are designed to be pulled to a potential customer's location, disconnected from the tow vehicle, moved around to a spot where the dish can 'see' the satellite without looking through a house or trees or hill, and then 'anchored down'.

Once in place you unreel your connecting cable, set the temporary satellite receiver inside the home and give a quick lesson in tuning the equipment to pick up the available programme channels. By leaving the rig in place over a weekend (or even overnight) the service literally sells itself; viewers then 'know' it works at <u>their</u> house, and with a sudden abundance of programming, they quickly develop a 'feel' for the excitement that goes with the service. Experience teaches us that from 50 to 70% of these overnight / over-weekend demos will result in a sale of a home dish system.

All of this will require some adaptation of your present business to the new format. At the very least, you will be required to step up to a more 'public' image in your community.

WHAT THE CONSUMER CAN EXPECT

Very few (if indeed any) programming 'channels' will stand-alone; that is, they will be offered in a 'programming package' which you in turn will 'sell' as "*so many channels for so many dollars, per month.*"

We'll use our SSD example here. The basic package will include (1) a <u>movie</u> channel, (2) a <u>sports</u> channel, (3) a <u>news</u> channel. The price

BBC World Service TV is a likely TVNZ offering

will be in the range of NZ$44 per month. To that 'basic' package a customer will have the optional choice of additional channels that will include (4) a children's channel and (5) a 'world service channel' (such as the BBC World Service TV). Other choices will be available as the service matures and beyond 'basic' the optional channels will cost the consumer between $10 and $15 per month each. Into the future special interest channels will include a business news service, a nature-oriented service, a music channel and a shopping channel. Within five years the number of 'programme channels' available should number close to 20.

All of these programming services will recognise that you, the installing dealer, have the most direct contact with the new viewing subscriber and will make you a part of their selling system for at least new subscriber packages. This will include a profit-incentive to your firm to 'sell' the new customer their particular programming package. While there may be only a single programme 'package' offered initially (in early days) shortly there will be competitive programming packages on offer and programmers recognise that 'brand loyalty' to their packages is an important part of their own success.

If you are uncomfortable with this aspect of the business, if you feel all you want to do with satellites is package and install systems, this might be a good time to begin looking for a 'partner' who can handle the public side of the business. Having one individual responsible for the sales and PR while another stays behind the scenes making certain the technology works is not a bad approach.

WHAT IS A SYSTEM?

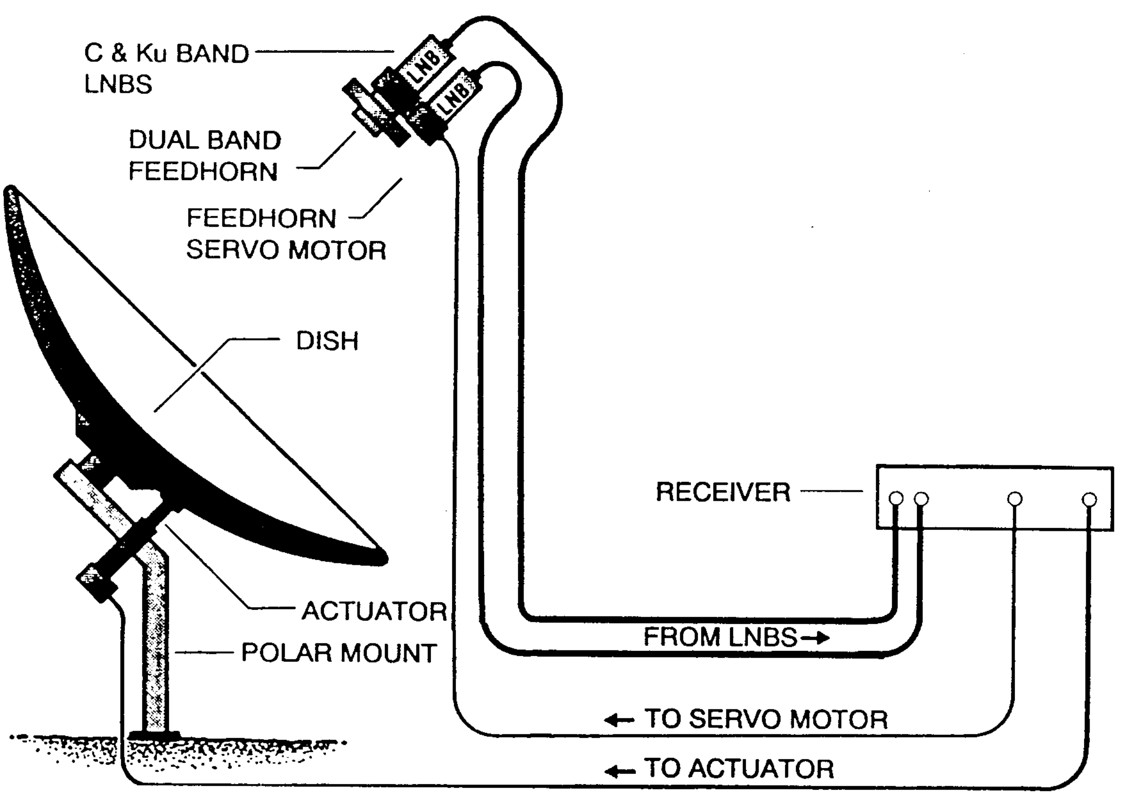
The elements of a home dish system are:

1) The dish, a parabolic reflector with gain a function of dish size. The original dishes for C and Ku band had a true parabolic shape and the energy captured by the reflective surface was focused to a central point ('prime focus') directly in front of the dish. Later versions use an 'offset formula' with the feed mounted low on the dish 'offset from centre'.

2) The mount is simply a system to hold the dish upright at the chosen location, with two built-in angular adjustments. One is for correct setting of the dish elevation (no matter where you are, the satellite is always 'up') and the other allows side to side tracking (azimuth). The satellite is a (tiny) 'spot' in the sky and the dish must be aimed at it with great precision.

3) If the dish is fixed in position (i.e., aimed at installation and left permanently pointing at the satellite) the complexity of cabling between the dish and the satellite receiver is reduced. The assumption at this point is that the majority of (first year) New Zealand DTH dishes will receive programming from a single satellite, and will therefore not require complex dish to receiver cabling.

4) At the dish there are two additional system elements; the feed antenna and the LNB. The feed antenna is a miniature receiving antenna designed to 'see' only the reflective surface of the reflector. The energy captured by the reflector is redirected to the feed antenna. The feed antenna is physically attached (often arriving to the installer already attached) to the LNB. The Low Noise Block downconverter combines amplification at the satellite frequency band with a frequency downconverter. Ku band



C + Ku bands home dish; top of the line system. Note a single feed covering C <u>and</u> Ku is used, but separate LNBs are required. Receiver has built-in dish and polarisation controller and display functions.

(12 GHz frequency range) satellite signals enter the feedhorn and lower frequency signals exit the LNB (such as 900-1400 MHz).

5) At the opposite end of the cable is the <u>satellite receiver</u>. In pure technical terms the satellite receiver is a 'translator' that processes the peculiar to satellite FM format video/audio signals to a new signal which can be used by a standard (PAL) television receiver.

THE SATELLITE FORMAT

A standard VHF-only television receiver can receive UHF television signals if a frequency translation device (such as a SKY 'decoder') is inserted between the aerial and the TV set. This works because a UHF television signal has no important technical standard differences from a VHF television signal.

A satellite signal has no technical features even similar to VHF or UHF television. A VHF signal is contained within a 7 MHz channel (8 MHz for UHF) while a satellite signal occupies a bandwidth of 27, 36 or 54 MHz. A VHF television signal is amplitude modulated video, frequency modulated audio. A satellite signal is frequency modulated video and the audio is frequency modulated on a sub-carrier (not dissimilar to the way FM radio broadcasting transmits stereo on a subcarrier).

These differences (there are many more) mean you cannot design a satellite receiver by simply creating a 'frequency converter' to shift the satellite frequencies down to the tuning range of a standard TV set. FM video does not demodulate (display) on a receiver designed for AM video. And a 'channel' 27/36/54 MHz wide will not fit into a TV receiver processing system designed for a signal 7 or 8 MHz wide.

The satellite receiver is purpose designed for the format employed by satellite broadcasters. The receiver 'translates' the original FM format video and audio to an AM format video signal accompanied by an FM format audio signal which allows you to connect the output of the satellite receiver to the input of your existing TV receiver (or VCR). The final stage of the satellite receiver contains the same type of low power TV modulator that you are familiar with in VCRs. Just ahead of this stage is a demodulator stage that converts the FM video and FM subcarrier audio of the satellite signal into 'baseband video' and 'baseband audio;' the same sort of 'video out' and 'audio out' signals you have from the rear apron of VCRs.

THE FREQUENCY ELEMENT

The standard satellite 'broadcasting bands' are:
C-band: 3,700 to 4,200 megahertz
Ku-band: 11,700 to 12,750 megahertz

Let's put those frequencies into wavelength perspective. One wavelength at:
Channel 1 is 6.625 metres long
Channel 11 is 1.343 metres long
Channel 27 is 0.577 metres long
Channel 62 is 0.375 metres long
C-band satellite is 0.075 metres long
Ku-band satellite is 0.025 metres long

A New Zealand 10 cent coin is 0.023 metres in diameter. If you laid out a line of 288 of these coins you would have the length of a channel 1 wave. So, Ku band satellite is 1/288th as long as TV channel 1.

To state it another way, everything about the Ku band receiving system must be done to an accuracy that is 288 times greater than the accuracy required for a TV channel 1 installation. Got the picture? You won't get the picture unless you upgrade your installation skills by a factor of 288 times!

THE GAIN EQUATION

A satellite in geostationary (so-called Clarke Orbit after system creator **Arthur C. Clarke**) is 'fixed' in position in orbit above the earth. This magic is made possible by the geometry of our earth's rotational speed. You are aware that from any fixed point on earth the earth will spin on its axis once every 24 hours. Out in space but relatively close to earth a 'body' placed into a circular orbit around the earth will rotate the earth once every 24 hours as well, provided the forward speed of the body matches the rotational speed of the earth times the increased distance of the body from the centre of the earth.

Geo-stationary orbit was calculated mathematically by Clarke in 1945 after he took into consideration the effects of gravity on a body placed into orbit. He calculated, somewhat to the amazement of physicists, that a 'satellite' placed approximately 36,000km above the earth and directly over the equator would match the rotational speed of the earth and therefore appear to 'hover in space' for an observer located on the earth's surface.

Once Clarke calculated a satellite in geo-stationary orbit above the earth, he next calculated how a transmitter placed inside of the satellite connected to an antenna mounted on the satellite would 'cover' the earth with signal. Using 3,000 megacycles for his calculations, Clarke proved mathematically that a transmitter of 'X' power would place a signal of 'Y' intensity over approximately 40% of the earth's surface. Every aspect of satellite engineering today originates from those 1945 calculations.

A Clarke orbit satellite has 'line of sight' transmission to any point on earth within its 40% of earth 'coverage reach'. Thus the signal loss between the satellite and the earth can be calculated as 'free space loss' of the signal. Free space loss is sensitive to the frequency of the transmission; at C-band the loss from a satellite approximates 196dB to most locations while at Ku-band it approximates 205dB. As you can see, the loss at Ku is slightly greater than the loss at C.

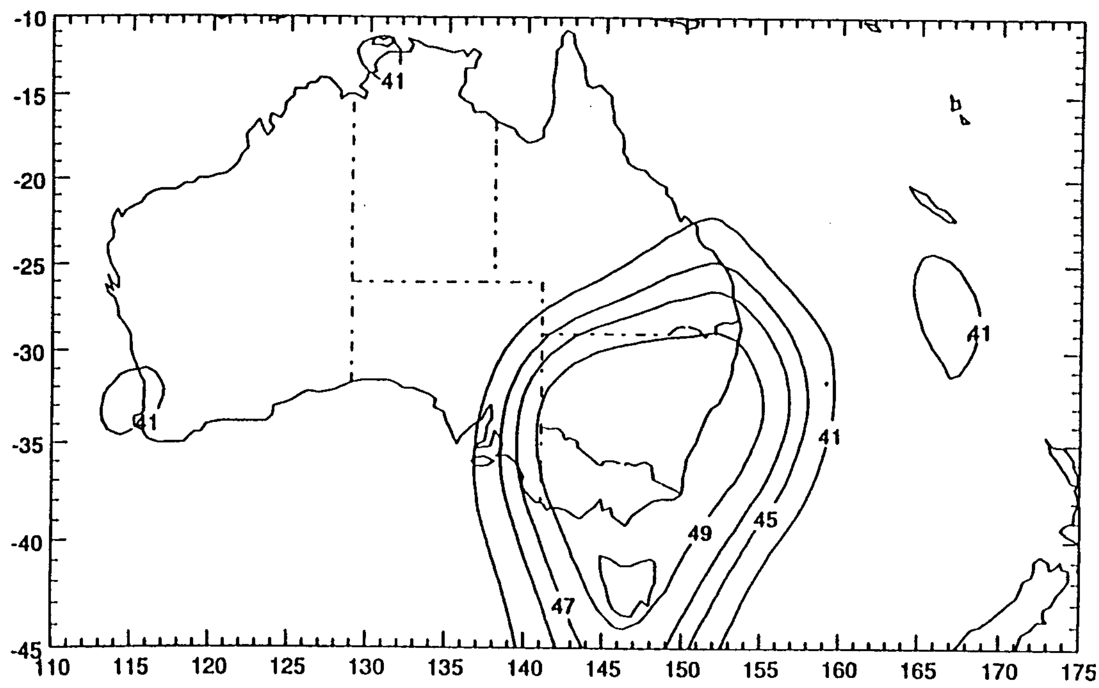
By knowing quite precisely the free space loss between the satellite's transmitting antenna and your receiving antenna, the business of calculating the 'gain requirements' for your receiving system is quite straight forward. Your receiving system must overcome the losses and provide a suitable 'margin' of signal to create a noise-free set of video and audio displays at the receiver.

Satellite operators such as PanAmSat do most of this calculation for you. First they take their transmitter output (in the 10-60 watt range) and calculate the 'multiplying factor' they receive from the 'gain' of their transmit antenna. In this calculation a transmitter with one watt output is assigned a power 'value' of 0 dBw; that means no-dB above the threshold of 1 watt. A transmitter with 2 watts output has 3 dB more power than 1 watt so this makes the total output now 3 dBw; i.e., 3 dB more than 1 watt. A transmitter with 32 watts output (such as Optus at full power) has a transmission power of +15 dBw.

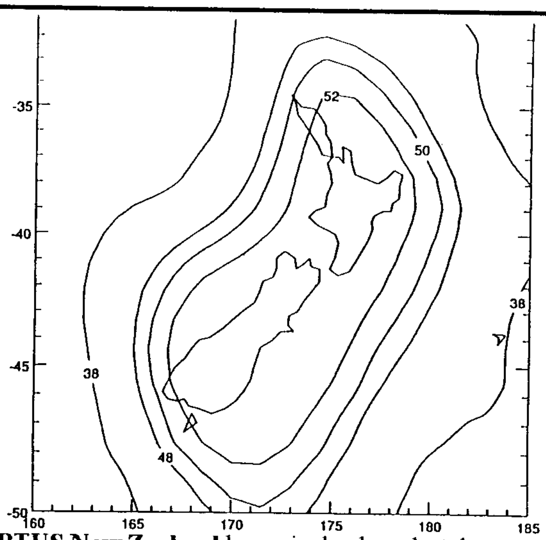
The gain of the transmitting antenna is now added to the effective power of the satellite transmitter. Fortunately at Ku-band, a transmitting antenna of modest size (0.35 metres diameter) has high gain; as much as 36 dB when referenced to an isotropic dipole (**Tech Bulletin** 9302; p.5).

Satellite operators merge the gain of the transmitting antenna with the dBw reference transmitter output power to create 'Satellite Footprint Maps' and we show examples of such maps here. These maps tell the satellite receive system installer precisely the amount of 'signal available' on the ground at a specific location.

These 'dBw coverage contours' result from the use of high-gain, directional transmitting antennas on board the satellite. Recall that a satellite in Clarke Orbit can 'see' (i.e., has line of sight to) approximately 40% of the earth's surface. It is possible to transmit to all of this area if the satellite operator wishes but in electing to do so the transmitter power (in watts) is now spread out over a much larger region. This results in fewer watts to any specific earth location since the available power



OPTUS B1 satellite 'SE Beam' (used by Australian ABC on transponder 7, Ku) stops far short of New Zealand



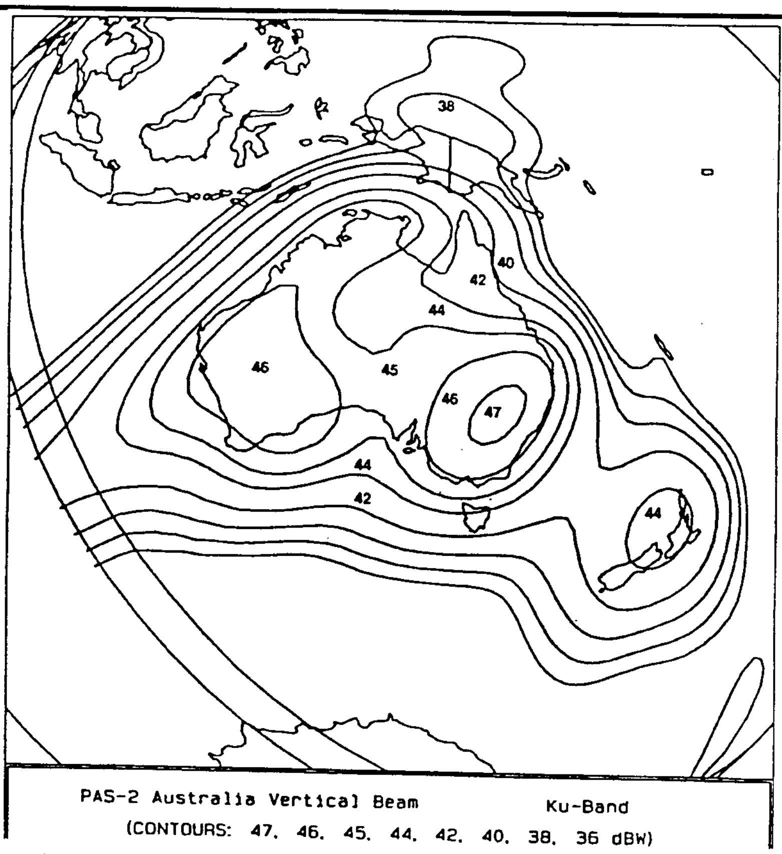
OPTUS New Zealand beam is dead on, but, has no customers so is seldom turned on except for test.

must be evenly proportioned out to the 40% of the earth which the satellite can 'see.'

In the Pacific Ocean Region (POR) a significant part of the earth is water and setting side the occasional need to communicate to maritime interests, the 'watts' sent down to the ocean are essentially wasted. For this reason the satellite designers create transmitting antennas which have enhanced gain in some directions, lower gain in other directions. The centre of the signal beam is called 'boresight;' that spot where the maximum amount of transmission power is 'focused' or concentrated. And like any antenna system, the further you are from boresight the lower the amount of antenna gain towards you.

If we have a 32 watt transmitter (+15 dBw) and we connect it to a satellite transmitting antenna with 36 dB of gain at the antenna's boresight, the effective power radiated back to earth at the boresight point is simply 15 + 36 or (+) 51 dBw.

Knowing this, we can now calculate the required 'gain' of our satellite receiving system



PanAmSat PAS-2, scheduled for July 8 launch, should provide 'healthy' 0.9 to 1.2 metre class Ku footprints over New Zealand homes. The satellite was designed for direct-to-home service.

located at boresight, or at any other point within the footprint area.

If the free space loss between satellite and you is 205 dB, and the satellite is sending 51 dB of signal towards us, the gain requirement for our receiving system will be 205 - 51 or 154 dB.

That, however, would result in a signal at the output of our receiving system that has 0 dB of signal to noise ratio. Like any TV receiving system, the signal (called C or carrier in the satellite business) must be some number of dB stronger than the noise to create a viewable picture (and listenable sound).

The magic number in a frequency modulated carrier video system is around 8 dB; in other words, when we get all done, if we desire pictures that are not blemished by noise, the satellite TV carrier must be at least 8 dB stronger than the system noise (**Tech Bulletin**: 9302, p.4).

So to the 154 dB of our first calculation we must now add back at least 8 dB to climb out of the noise and produce a suitable quality picture on a TV screen. The result, 162 dB, is the minimum gain we require in the satellite receiving system. But (voltage) gain is only part of the requirement.

dB Noise Figure	Kelvin Temp	dB noise Figure	Kelvin Temp
2.0 dB	170	1.0 dB	75
1.9 dB	159	0.9 dB	67
1.8 dB	149	**0.8 dB/B**	59
1.7 dB	139	0.7 dB	51
1.6 dB	129	0.6 dB	43
1.5 dB	120	0.5 dB	**35/A**
1.4 dB	110	0.4 dB	28
1.3 dB	101	0.3 dB	28
1.2 dB	92	0.2 dB	14
1.1 dB	84	0.1 dB	7

2.0 dB/170 range temperatures at C were common 10 years ago. **A/** is state of present C; **B/** is state of present Ku (lower by the year).

THE NOISE ELEMENT

Noise is a form of interference. At C or Ku satellite frequencies for all practical purposes the only noise present in the receiving system is generated within the system itself. Outside influences such as power lines or automobile ignition systems are not a factor at these frequencies.

Noise created or generated within a receiving system is thermal or 'shot noise' created when electrons flow. In other words, the transistors and component parts inside of the satellite receiving system create noise as they perform their assigned tasks.

The ideal satellite receiver generates no (electron) noise. Such a receiver pushes the law of physics just a tad since the flow of electricity involves the movement of electrons and once you have electrons moving you have noise being generated. To have a no noise receiver you must stop the flow of electrons; accomplished only by turning off the electricity required to operate the receiver. A true 'Catch 22.'

But, circuit designers have slowly evolved component parts which generate very little noise while still meeting the basic requirements of the circuit.

The most critical portion of the satellite receiver for noise is the first set of amplifier stages the satellite signals encounter as they flow through the 'feed antenna' into the LNB unit. LNBs are rated and sold based upon the amount of noise they create. The lower the amount of noise, the better the LNB quality. Noise generated within the LNB is specified or measured by with one of two systems: by noise temperature degrees on the Kelvin temperature scale, or, by something called noise figure.

At C-band, almost all LNBs have manufacturer specified noise temperatures in the degrees Kelvin scale. At Ku-band for no particular reason the LNBs are specified in noise figure. The two scales are interchangeable (see chart here) and mean the same thing even if they use two different scales to state the noise contribution within a device.

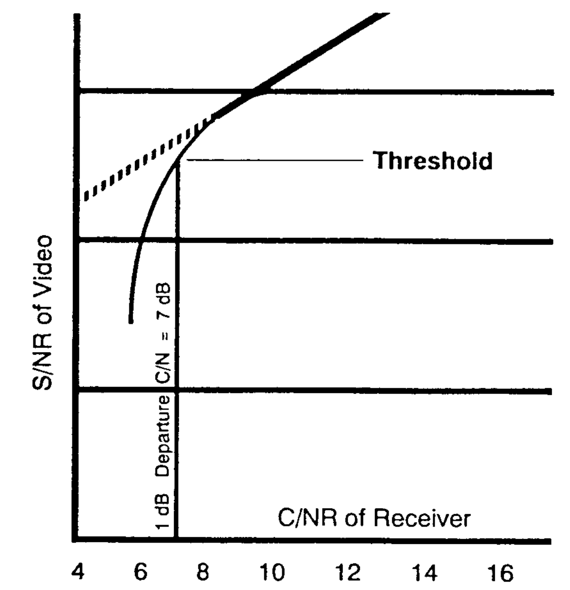
'Low noise' is a relative factor. The relationship between noise contributed in the LNB and the quality of the satellite receiving system picture is mostly a logarithmic, not linear, function. Thus a very small reduction in noise temperature or noise figure produces a quite dramatic increase in picture quality on a satellite receiver.

Recall that to produce a high quality picture for a viewer, the CNR (carrier to noise ratio) of the satellite signal should be at least 8 dB; meaning there is 8 dB more carrier presented to the receiver than noise.

There is with frequency modulated video something known as the 'threshold effect.' If you were in a laboratory with very carefully controlled signal levels present, you would observe that picture-noise (called sparklies but akin to 'snow' in a terrestrial fringe area picture) changed very rapidly as the carrier level from the test transmitter increases and approaches the 8 dB CNR region. The 'threshold' for no noise in the picture is quite dramatic; a test signal of 7.5 dB CNR, for example, will have numerous 'hits' (bits of sparklie noise) marring the reception. By increasing the signal to the receiver just 0.5 dB, suddenly the sparklies are gone!

This is the threshold, the point on a particular receiver where quite suddenly the picture clears up and you have moved from the fringe area equivalent in terrestrial TV to a studio-quality picture. Because the threshold occurs so abruptly, even very small mistakes (errors) in the receiving system installation can shift you from above to below threshold. An antenna alignment error at VHF channel 1 (or 11 or 27) creating a 1/2 dB 'error' would never be noticed; at Ku band it is dramatic!

In most home installations, you will hope to have a 'margin' of extra signal available such that when the system is peaked up to maximum performance your CNR is 10,11 or even 12 dB.



Video SNR increases very rapidly for each additional dB of CNR until 'threshold'; thereafter 1dB CNR and SNR become 'more linear'

The difference between threshold (8 dB CNR) and the strongest signal your installation produces is the 'margin' of the system.

In an example system, let us install a 0.9 metre dish for PanAmSat PAS-2 and measure a CNR or exactly 8 dB. This means that with this particular dish and electronics, we have 0 dB margin and everything must be 'spot on' to produce the sparklie free picture the customer anticipates.

Now, we exchange the 0.9 metre dish for a 1.2 metre dish. The gain is 39 dB for the 0.9 metre dish at Ku and 41.5 dB for the 1.2 metre dish; a gain improvement of 2.5 dB. With the 1.2 metre dish we should be able to measure a CNR of 8 plus 2.5 dB or 10.5 dB. The extra 2.5 dB is our margin. With this margin available, the pointing accuracy of the dish at the satellite could be 'off' or the quality of the LNB could be 'down' and we would still have a comfortable 8 dB CNR for the customer. On the other hand, if we had stayed with a 0.9 metre dish there was no margin; the dish must be dead-on the satellite (no pointing error), and the LNB must work to 100% of its rated efficiency if we are going to produce the 'threshold' CNR of 8 dB.

VARIABLES

Although the satellite has 'line of sight' view to the receive terminal, and for any satellites New Zealand will be utilising for DBS reception we will be within the intended 'footprint' of the satellite, there are still two variables the installer must consider:

One: Equipment install error and ageing. Ageing is a minor additional problem. The performance of the electronics should be as good five years after the installation as the day it is installed. However, cable connections and 'weathering' of the outside portion can be a problem as we shall discuss.

Two: Rain 'fades.' A 'clear' line of sight to the satellite assumes air with a relatively minor moisture content. When the moisture increases, the losses on the 'path' go up. Recall that a full wavelength at Ku band is around 25mm across. Not many 'rain drops' approach this size but the cumulative effects of a heavy rain storm can be significant at Ku. Quantitative measurements have been made for two decades on the effects of heavy rain on Ku band signals passing (down) through various rainfall rates and a serious scenario is a rain storm dumping 50mm of water per hour between your satellite receiving dish and the clear air above, causing the path to 'lose' 6 dB of signal.

Remember the 'margin?' If your margin for a particular installation is 2.5 dB, a 6 dB 'rain fade' will instantly appear as a lowering of the satellite signal to a point 3.5 dB below threshold. Given these numbers, your DTH customer will experience heavy 'sparklies' on the picture (and an accompanying noisy audio channel) for as long as the heavy rainfall continues.

It doesn't happen very often; it could well happen when your customer isn't even using their TV set.

Of greater concern, especially in areas where rainfall is frequent (if not often intense) is a reduction of 1 to 2 dB of signal when the rainfall is more moderate; say 10mm per hour. That's good for around 1.5 dB of additional path loss. If you sold and installed a terminal with a 2.5 dB 'margin,' the 1.5 dB additional loss due to a 10mm rainfall will still not be noticed. If, on the other hand, your installation just makes threshold (a 8 dB CNR), the extra 1.5 dB will send the reception into 'sparklies' with even moderate rain.

The message here is that if the dish is installed with 'clear fine weather' and you have to use every bit of antenna pointing skills to reach receiver 'threshold', you can expect some viewer problems when the rain falls.

LNB GAIN vs. CABLE LOSSES

The two most important measurement parameters for an LNB are noise temperature / noise figure, and gain. A poor (too noisy) temperature will degrade the quality of the signal. It works out this way:

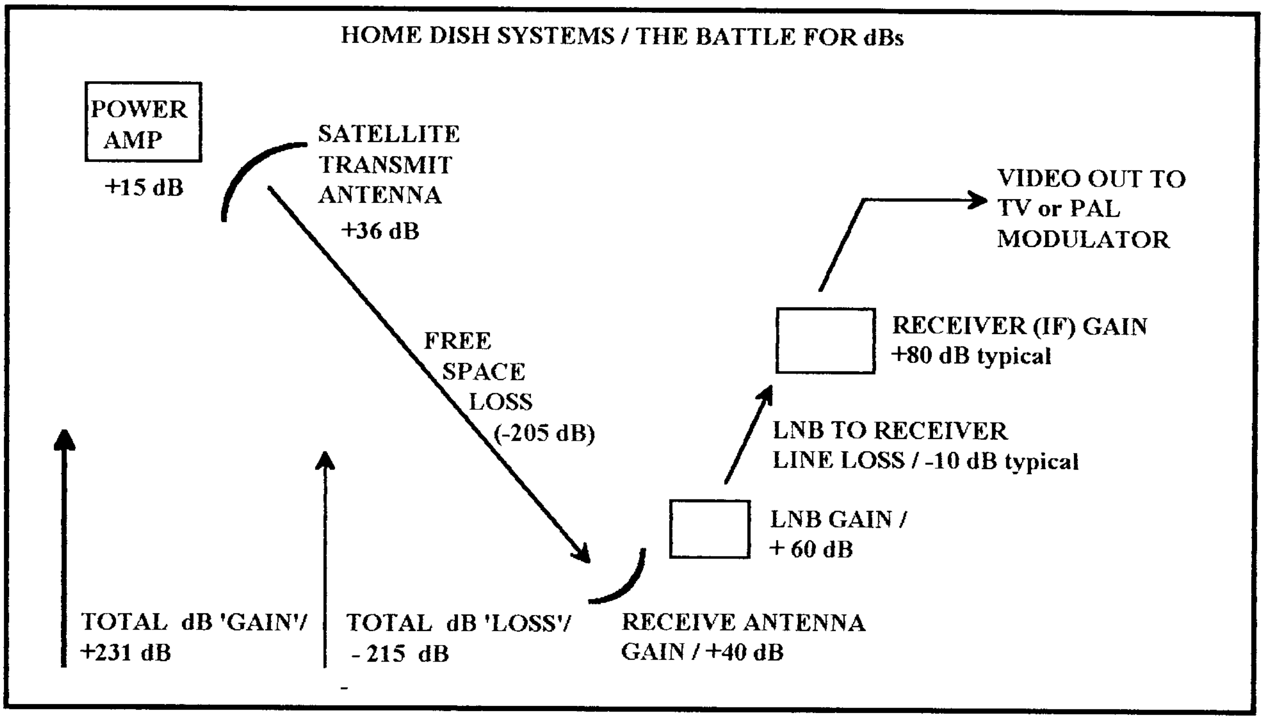
For every reduction in noise temperature of 40 degrees Kelvin, the CNR will improve 0.6 dB. Note there are variables in this equation and this statement averages those variables.

Therefore, let's say you have chosen an LNB with a noise temperature of 100 degrees (same as 1.29 dB noise figure / nf). And you find your pictures are just below threshold. By upgrading the LNB to a 60 degree unit (same as 0.82 dB nf) we gain 0.6 dB CNR. If the CNR was 7.5 dB with the 1.29 dB unit, with a 0.82 dB unit it will become 8.1 dB (just above the average receiver threshold).

What about LNB gain? Doesn't that count for something?

This is a difficult concept to grasp for many installers. The gain of the LNB is important, but in most installations the amount of gain will have no bearing whatsoever on the CNR of the signal being received.

Most LNB units have approximately 60 dB of gain. This gain is measured from the incoming



Ku band signal to the output at the back of the LNB where the intermediate frequency range (IF) signal goes into the interconnecting cable.

The total system gain is important (remember the path loss from satellite to receiving antenna is in the range of 205 dB at Ku; we need sufficient receive installation gain to overcome this path loss plus at least 8 dB).

If you sum the various gains in the system, you will find:

a) Transmit power gain (reference 1 watt of transmitter power) - 15 dB region

b) Transmit antenna gain - 36 dB region

c) Receive antenna gain - 40 dB region

d) LNB - 60 dB region

Which puts us at 151 dB of gain before we go into the cable connecting the LNB to the receiver.

e) The receiver proper where gain is measured from the input of the IF signal to the output of the demodulator stage. This is typically in the 80 dB region.

The sum of these gains is therefore in excess of 230 dB. Weigh that against the circuit losses from the satellite to our receive terminal (-205 dB) and you will see you have around 25 dB of excess gain (some of which will be 'lost'; in the cable connecting the LNB to the receiver; see diagram here).

Gain means (signal) voltage amplification. It must never be confused with the overriding need to maintain a threshold CNR at the demodulator stage (8 dB or more). In AM system terms, CNR is the same as signal to noise ratio (SNR). If you understand SNR in terrestrial systems, you are aware that for a picture to be on the edge of snow (i.e., just above the point where noise or snow starts to appear in the picture) requires an SNR of 40 dB minimum (**Tech Bulletin** 9302, page 2). If satellite signals were amplitude modulated, we would never create noise free (i.e., above threshold) signals with an SNR of 8 dB!

To complete the calculations, we have to consider the cable losses between the LNB output and the receiver input. The intermediate frequency (IF) range of 900-1400 (or 950-1450 or a wider range of 900 to even 2100 in the most recent receivers) is the frequency of concern when selecting an interconnecting cable for the run from LNB to receiver.

Typical cables carrying signals between 900 and 2100 megahertz lose a significant amount of signal per 100 feet / 30 metres of cable. Regular (non-foam dielectric) RG-59 series cables have typical losses of 11.0 dB per 100 feet / 30 metres at 900 MHz, rising to 15.2 dB at 2000 MHz. The lower loss RG-6/U foam dielectric family of cables have losses of 8.1 dB at 900 MHz rising to around 12.7 dB at 2000 MHz.

As a rule of thumb, based upon millions of installations, if your LNB has at least 60 dB of gain you can use RG-59 family cable for runs of up to 100 feet / 30 metres. For longer runs, go to the foam dielectric family cables. What about larger diameter RG-11 family cables for 'very long runs?' If the 11 series cable is foam dielectric, it will be slightly better (by one dB or so) then 6 series foam dielectric cables. If the 11 is a non-foam (i.e., solid dielectric) it will actually be worse than foam dielectric RG-6 family cable. The safest cable to use in most installations is a 6-family foam.

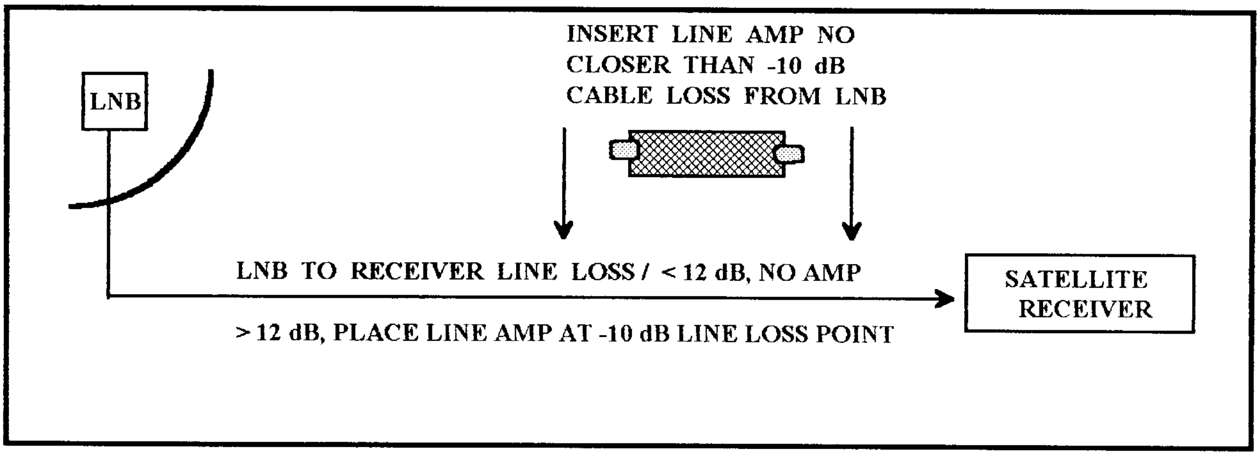
When the cable loss exceeds 12 to 15 dB at the highest frequency in the IF range (such as 2000 MHz for some LNBs, 2100 for others), it is time to consider using a line amplifier.

Line amplifiers are frequently misused by installers who do not understand their purpose. A line amplifier is a signal voltage amplifier. Typical gain values are 10 dB of line voltage gain, or, 15 or 20 dB. Yes, you can 'stack' line amplifiers for more gain but only if it is done properly.

A line amplifier will do nothing to improve your CNR if the CNR is low at the output of the LNB. You will not get better pictures, you may actually get worse pictures, if you install a line amplifier on a cable that is short and does not need additional line voltage gain. A system with a 7 dB CNR (i.e., below threshold and sparklies in the picture) gets worse, not better, if a line amplifier is added when it is not needed. Why? The satellite receiver has an automatic gain control function, like any TV set. When you add a line amplifier and increase the signal voltage to the receiver, the receiver's AGC system interprets this as an increase in carrier level. It lowers the gain of the receiver and in doing this reduces the CNR of the signal by raising the receiver's noise level in the process of reducing the gain. The net result is the receiver gets more signal voltage, but it produces a lower carrier to noise ratio. Adding a line amplifier when it is not required is a mistake; a bad mistake.

So when do you need one? And where do you insert it into the line?

A line amplifier is a very simple (and inexpensive) broadbanded gain device; often a single stage (IC) covering a frequency range such as 500 to 2000 MHz. It is not a piece of laboratory equipment, it does not have a 'quality' noise figure of its own. It comes to you with 'F' series connectors on the input and



output and you provide operating voltage to it through the cable that interconnects the receiver to the LNB; a point we shall return to, shortly.

The line amplifier has a rated 'dynamic range' and one of the common mistakes is to place the line amplifier in the wrong place on the line. The worst possible place for the line amplifier is at or close to the output of the LNB. At this point the LNB delivered IF signal levels are still very strong, and by placing the line amplifier close to the LNB two bad things happen:

a) The line amplifier is over driven (receives too much signal voltage from the LNB), and,

b) You exceed its internal 'dynamic range' causing it to generate internal noise.

Many receivers are equipped with a 'signal level meter' ('S' meter in ham radio jargon). Mistakenly, installers who are faced with less than above threshold pictures and unable to correctly figure out the problem grab a line amplifier from their tool case and stick it in the line.

The 'S' meter signal level meter jumps up and they think the problem is solved until they look at the pictures. Yes, even though the S meter reads higher, the pictures are in the best case no better and in the worst case they have an even lower CNR now the line amplifier is added.

One mark of a novice installer is he expects better pictures after the line amplifier is installed. Another novice mistake is to spend very much time agonising about the 'S meter' reading on the receiver. In other words, don't try to equate S meter readings to signal quality. The meter is a <u>very</u> relative indication of signal voltage. It is not related to the signal CNR in any way, and it is possible to create an S meter reading of full scale by simply removing the antenna/LNB entirely and replacing it with a pair of line amplifiers. In other words, the noise generated by the line amplifiers alone is sufficient to 'drive' an S meter to full scale reading. So how do you really know you need a line amplifier?

You may need a line amplifier for those installations where the cable losses are in excess of 12-15 dB between the LNB and the receiver. If a line amplifier has ten dB of gain, you say to yourself:

"If I start at the LNB, how far down this cable will I go before I have lost 10 dB of signal in cable losses?" That's where you cut the cable and insert the line amplifier.

If the line amplifier has 20 dB of gain, you will use it only when you have a cable causing more than 20 dB of line loss, and then you will place the line amplifier at the point on the cable where the line loss approximates 15-20 dB.

And, you are well advised not to stick in a 20 dB line amp where a 10 dB gain amp is called for; getting too much gain in the system is every bit as bad as not having enough signal.

The clues that you need a line amplifier are as follows:

1) Between the lower frequency channels (typically channels 1-2-3-4 on a receiver) and the higher frequency channels (a double digit number such as 24) the picture <u>quality</u> 'falls off.' Because the higher frequency channels travel from the LNB to the receiver at a higher intermediate frequency (IF), the interconnecting cable losses will be worse on the higher channels. Thus cable loss will degrade picture quality first at the higher channels; just like the difference between UHF and VHF signals in coaxial cable.

2) The 'S' meter reads much higher on the lower channels than on the higher channels. <u>Stop!</u> First look at the picture <u>quality</u> on the higher channels. If you can see no quality difference between the higher and lower, forget what the S meter says. If the meter reads S7 on a channel 1 transponder and only S1 on a channel 24 transponder, but both pictures look the same, forget it. Remember, the meter is a relative indicator; it is not a piece of test equipment!

3) There seems to be two types of noise present. The first is the 'sparklie' noise which is unlike anything you have ever seen on terrestrial

TV; the colour noise dots look more like confetti than the simple black and white dots you are accustomed to with terrestrial TV. These sparklie dots can only be caused in the FM demodulator; i.e., they can only come from too low a CNR. Adding a line amplifier will not improve the sparklies.

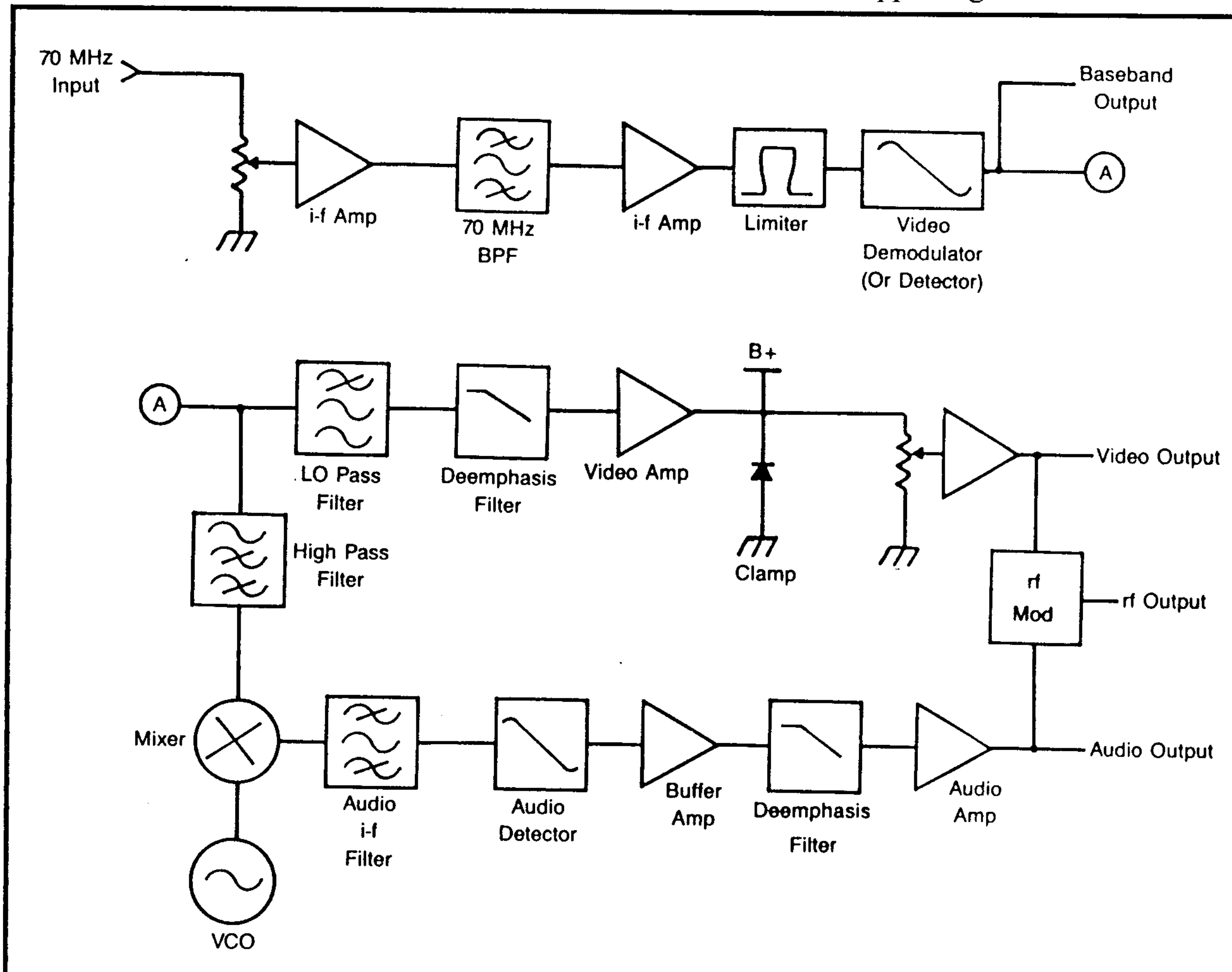
The second kind of noise is the more familiar to terrestrial fringe area installers; a 'graininess', or the true 'snow' of terrestrial TV. This may be an indication that you need a line amplifier, or, it could also mean you have too much IF gain operating. If you have a combination of high S meter readings and graininess, this says you have too much signal to the satellite receiver's FM demodulator. The solution is to go inside of the receiver and turn the IF gain control down. Adding a line amplifier in this situation will only make the pictures worse.

THE POWERING SCENARIO

The indoor receiver operates from 230vac/50 cycles, like all other consumer appliances. The outdoor LNB portion operates from a DC voltage; +18 is not uncommon.

The coaxial cable that interconnects the receiver to the LNB carries the voltage to the LNB; the current demands are modest (under 200 mils typically).

At the receiver input where the LNB IF signal enters you have a broad frequency band stage of additional gain; 'IF' gain to be precise. The receiver power supply places +18vdc on the 'F' series connector appearing on the back of the



EARLY HOME satellite receivers looked like this using a 70 MHz single-transponder IF. Current crop uses 900 MHz upwards broadband IF, second conversion stage to range such as 70 MHz where signals are demodulated receiver where the LNB line inputs. There is a provision to allow the installer to 'turn off' the LNB powering voltage on that F fitting for those situations where the LNB is not powered by the receiver. Some receivers supply a separate fuse on this line should there be a fault on the line.

If the system includes a line amplifier, power for it comes through the line. The line amp operating voltage is the same as the LNB so while the power is passing from receiver to LNB it flows through the line amp where sufficient current to run the line amp is sampled from the powering source.

MULTI-POLARISATION SIGNALS

Modern satellites employ a system of 'frequency reuse' by taking advantage of the natural discrimination at receivers between vertically polarised and horizontally polarised signals.

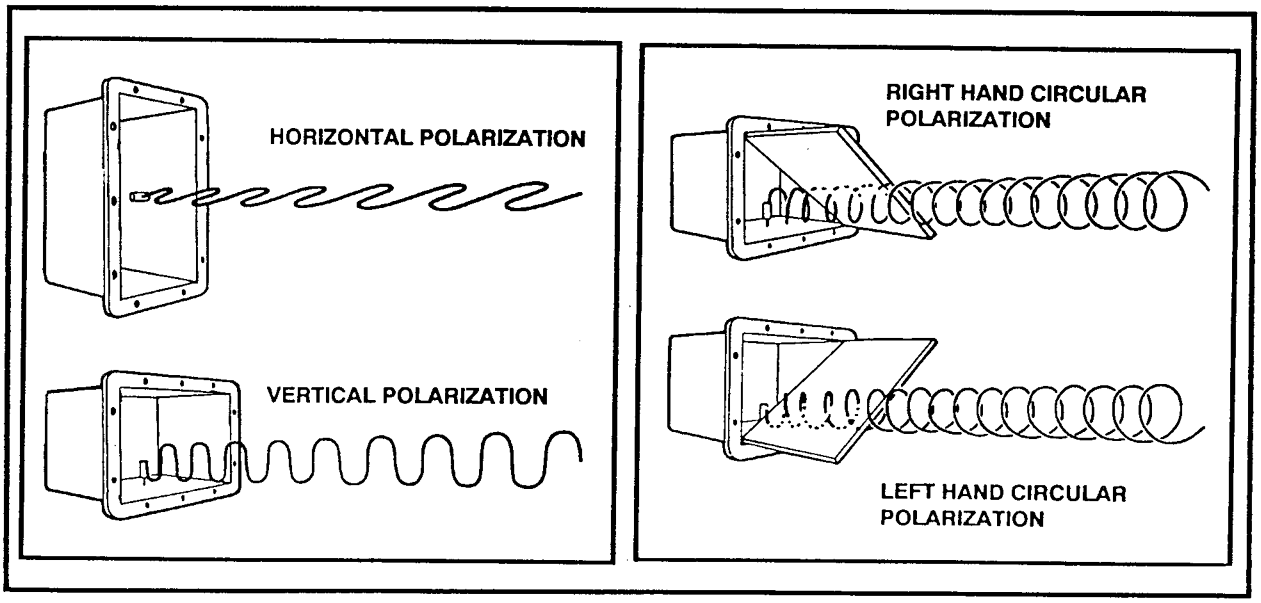
New Zealand terrestrial transmitters employ both vertical and horizontal polarisation modes. Your experience as an installer of consumer TV receivers and antennas has taught you that if you want the best pictures from local TV transmitters, your antenna installations must match the polarisation of the local transmitters.

Terrestrial transmitters are amplitude modulated and in the best case a vertically polarised terrestrial TV antenna will still detect the presence of a horizontally polarised signal (on the same channel) by displaying co-channel interference lines (horizontal across the screen: **Tech Bulletin** 9301; p.2).

In the satellite world the TV signals are frequency modulated and there is a special situation called the 'capture effect' with FM signals. The capture effect ignores the presence of an interfering co-channel FM signal until the interfering carrier is with 1-3 dB of being the same strength as the desired signal. This means you can tolerate the presence of a non-desired FM signal even on the same channel far better than you can with amplitude modulated video.

PanAmSat will employ both vertical and horizontal polarisation for its TV signals. Over on Intelsat, the present C band satellites (**Coop's Technology Digest**: 9311, p.2; 9312, p.2) employ circular polarisation which can be right hand (RHC) or left hand (LHC) and these 'opposite polarisations' have the same effect in circular as vertical and horizontal do with 'linear polarisations.'

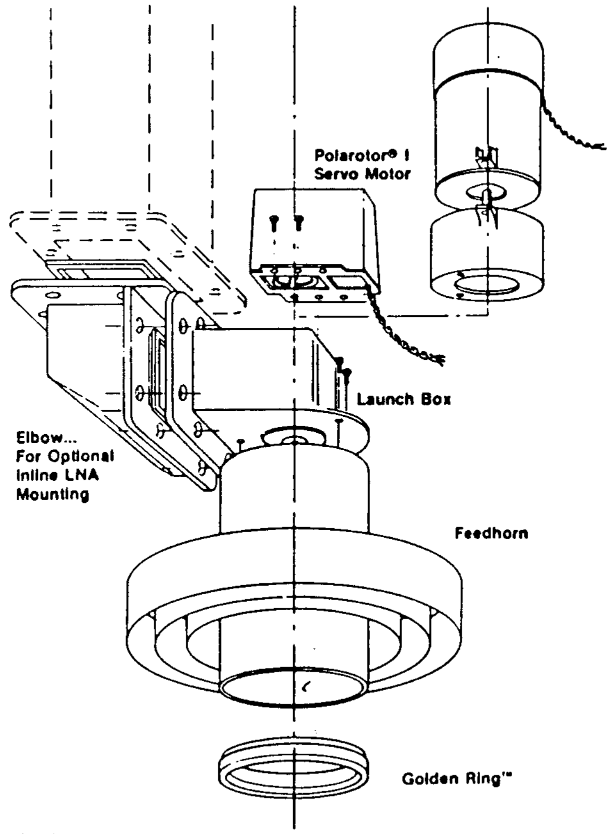
To further ensure that TV signals transmitted on vertical transmit antennas do not interfere with TV signals transmitted on horizontal antennas, PanAmSat also adjusts the operating frequencies such that no two transmitters use the exact same frequency space. Thus we have



the natural 'capture effect' protection of linear vertical and linear horizontal as well as a frequency-offset working to avoid any signs of the vertical signals at the horizontally polarised DBS receive terminal. For the home dish owner, this frequency re-use system is a very efficient way of doubling the number of possible TV programme channels. A twelve channel receiver (that tunes a 500 MHz spectrum chunk) becomes a 24 programme receiver simply by performing a small change at the LNB.

It is entirely possible that PanAmSat (or a future generation satellite) will send TV programming to New Zealand employing programme channels that are linear vertical and linear horizontal. In this case the terminals you will be installing will have to include some method of 'switching polarisations' between vertical and horizontal. Ideally, this switching will be automatic so that when a viewer dials up channel 1 (for example) the receiver responds by being connected to the horizontal portion of the feed system antenna. And, when the viewer switches to channel 2 on the satellite receiver, the receiver changes to the opposite (vertical) polarised section of the feed antenna.

There are several different approaches to this polarisation switching. The switching involves the feed antenna which has a small 'probe' or sub-antenna element buried down inside of the LNB feed shroud. This probe has a physical shape and that shape and the position of the probe determines whether it 'looks at' vertical or horizontal signals. If you rotate or turn the probe with a small motor that is activated by the receiver's channel switching, the probe is aligned with the polarisation of the TV signal. Each time you switch channels from a channel



CHAPARRAL 'Polarotor' is one of many devices created to 'switch' polarisations at antenna by remote control from the receiver. Actual 'feed antenna' is probe, mounted inside of 'feedhorn' and not visible here.

that is horizontal to a channel that is vertical, the probe tracks to the required polarisation.

Another approach is for the LNB to have a pair of permanently fixed probes, one that is aligned with horizontal signals, one that is aligned with vertical. Now when the receiver changes channels the appropriate fixed probe is connected within the LNB.

There is one consideration here for the installing dealer:

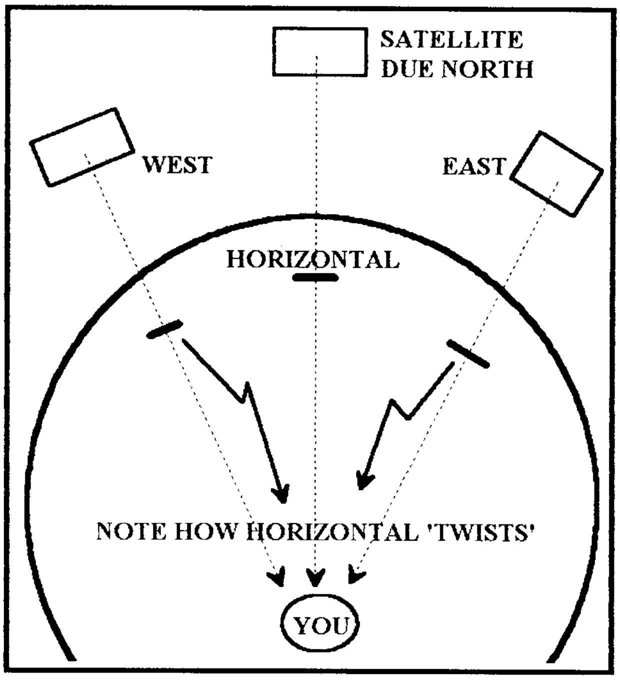
One: When the dish is installed, you perform an initial 'set-up' of the probe's alignment. The LNB fits onto a 'rotating collar' such that you can twist the feed portion of the LNB to initially align the feed probe with the polarisation of the incoming signal. If the LNB has only a single probe and it is fixed into position the alignment of the feed/LNB is a one-time set and forget step at the time of installation.

If the LNB uses a rotating probe feed, setting the probe properly for one polarisation will also fix it for the second (i.e., one adjustment does both). We'll see why shortly. So, too, if the LNB/feed uses a pair of discrete probes will the fixing it for one also align it for the second since the two polarisations are always 90 degrees separated (at right angles) to one another.

Now some background that you can accept and benefit from, or simply forget.

A satellite that is due-north of you (i.e., on the same longitude line as your receiving location) 'looks down at you' with its horizontal polarisation absolutely horizontal as you face the satellite. And, the vertical signal is straight up and down (vertical) as you 'look at' the satellite.

Each satellite using linear polarisation follows the same format; it positions the transmitting antenna feeds such that horizontal is horizontal and vertical is vertical for a point due south (or north in the case of northward looking satellites).



Assume for a moment the satellite of interest is located at 154 east while you are located at 174 east. Your 'view' of the satellite is from the 'side' and the horizontal and vertical polarised waves are now 'skewed' (twisted) away from horizontal and vertical. With the satellite west of your location (and pointing towards boresights in the southern hemisphere), the horizontal is now twisted (from your perspective) counter clockwise. Horizontal is now a straight line from perhaps 250 to 70 rather than 270-90 while vertical is a line that appears to you to be twisted from 0 - 180 to a new line that is 340-160 (with 0 being straight at the satellite or 12 o'clock on a watch face).

So when you set a fixed probe for alignment, it's actual alignment will depend upon where the satellite is reference your due north. If the satellite is east of due north for you, the polarisation will twist on your probe by some amount; if west of your location it will twist in the opposite direction. Once you have the probe aligned for a particular satellite, what happens when you move the dish to a new satellite? The probe's horizontal/vertical alignments must change. And? And, modern day receivers store in-memory the proper probe positions for each satellite if the probe is movable.

All you really have to remember is that as you make an installation, the LNB probe(s) must be aligned for peak signal from the linear polarised satellite signal as it arrives at your location. If you do not 'peak' this adjustment, your CNR 'margin' will be adversely affected (1).

SWITCHING VOLTAGES

If your feedhorn probe uses a small (DC) motor to rotate the probe, this requires an operating voltage. At the same time the probe's actual position at any instant must be 'fed back' to the receiver so the receiver knows when to switch the probe to a new alignment (a function of which channel the viewer has selected).

The operating voltage for the probe motor is typically in the 5vdc range and the receiver provides a terminal strip with this voltage, and, a 'pulse' signal on it. The 'pulse' signal is an electronic counting device which interrogates the feedhorn probe electronics asking "*Where are you pointed, now.*" The probe motor will swing the probe 1/4th of a circle (90 degrees) between vertical and horizontal. Thus once you have set up the system so that the probe aligns with either vertical or horizontal maximum signal on a satellite, when you switch channels to the opposite polarisation a voltage goes to the probe motor telling it to turn on just long enough to move the probe over 1/4th turn. Then the voltage shuts down and the pulse signal asks the probe to verify it has arrived at the new location.

All of this is automatic for the viewer once the installer sets up the individual installation. And if your installation uses 'fixed probes' (one each for both polarisations), the effect is the same; changing channels changes polarisation if the viewer has selected a new channel with a polarisation that is opposite to the channel they were previously watching.

1/ A probe 'between polarisations' responds to both creating noise not unlike sparklies as the carriers interfere

'INSIDE' THE POLAROTOR

A small servo (or DC) motor drives the 'probe' antenna through approximately 140 degrees of rotation. The probe is the 'pick up antenna' for the LNB and its position, relative to the incoming wavefront, determines whether it responds to vertical or horizontal polarised signals.

The motor's position (and thus the probe position) is controlled by a driver circuit. Pulse Width Modulation (PWM) signals originating at the receiver send varying width (length) pulses to the driver circuit; pulse widths of 0.8 to 2.2 ms are typical. At the probe rotator, the pulse length translates to a driving signal for the motor. A potentiometer provides feedback from the motor to indicate where the probe is located. A 1.5 ms pulse positions the probe in the centre of its range (i.e. +/- 70 degrees from either 'stop' end). Shorter pulses move the probe counter clockwise, longer pulses move it clockwise.

The pulses are typically standard TTL logic (+5 vdc and 0 volts) with a rep rate of 17 to 21 milliseconds.

To handle these probe switching functions typically requires two wires and a shield (ground). One wire is for the probe motor voltage (wire colour typically red), the second wire is for the probe's pulse counter (wire colour typically white) and the third wire is a ground wire for both circuits. Experience has taught us that the pulse signal on this line is subject to unwanted interference from nearby EMF fields. Objects such as HV lines, fence controllers create 'static pulses' which often 'fool' the pulse interrogator into thinking pulses are on the line. The solution is to use two wires with an aluminium foil 'shield' plus a separate ground wire.

DISH ROTATION?

To this point we have dealt with a single frequency band, single satellite installation. The assumption has been that a single satellite (such as PanAmSat PAS-2) will have all or most of the 'viewer desirable' programming which will initially interest New Zealand DBS viewers.

The 'packaging of programming' is clearly beyond the scope of this technical analysis and those requiring the best estimates of this rapidly changing area are referenced to **Coop's**

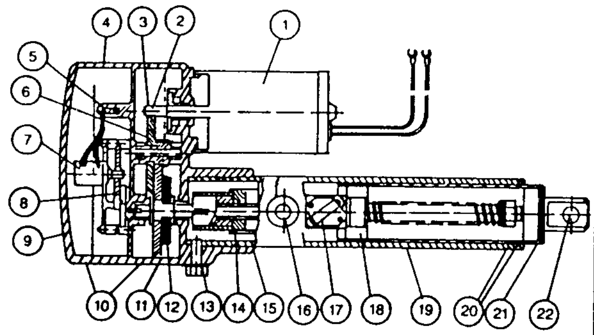
Technology Digest (2) which reports on this field in each issue. Still, if two or more satellites will carry programming of interest to New Zealand viewers, what happens to the dish that is fixed on a single satellite?

For experience we turn first to New Zealand in the mid 1980s when C band satellite service brought in AFRTS (and later CNN), and, to present day Europe.

A dish that moves laterally (east and west so as to point at each satellite as required) is a considerably more expensive installation than a fixed satellite dish created for alignment towards a single Clarke Orbit Belt satellite.

A dish that moves requires a motor system to move it. That alone is in the NZ$200 range in quantity. Most 'dish mover' motors are actually motorised 'jack screws' and their technology preceded satellite installations by many decades. A motor that moves the dish is seldom adequate for a consumer; knowledge of where the dish is pointing (at any instant) is also required. So to the motorised jack screw we add a 'dish controller' which can be a stand alone 'box' or the controller functions can be built into the receiver proper. The controller is semi intelligent; by using 'feedback' (a system very similar to be probe location pulse counting system) the controller keeps track of 'the location' as the dish moves. This feedback data is interrogated by the controller's microprocessor and this in turn creates a display that tells the viewer the relative position of the dish at any instant.

Simplistic controllers use sequential numbers (such as 1-250) that scroll on the display face as the dish moves. If the viewer knows or has been told by the installer that "147 on the counter is Optus B1 and 179 is PanAmSat 2" then the user pushes an 'east' or 'west' button on either the controller, the receiver, or on the hand held remote control and visually watches



Part No.	Description
1	DC Motor
2	Helical Gearing
3	Helical Gear
4	Hole (Wire In)
5	Wiring Board (Connection dc Motor)
6	Pinion Gear (Spur)
7	Potentiometer (10-Turn, 10K)
8	Gear (Position Sensing)
9	Housing (Die Cast Alloy-Zinc)
10	Gasket
11	Output Gear
12	Slip Clutch
13	Fasten Screw
14	Integral Brake
15	Glue (Water Resistance)
16	Mounting Trunnion
17	Ball Screw
18	Nut (Steel)
19	Outer Tube - Chromed Finished
20	Dust & Water-proof Seal (Double Lips x 2 Pieces)
21	Inner Tube-Chromed Finished
22	Head Hole with Bearing
23	Retract Limiter
24	Nut (Bronze)
25	ACME Screw
26	Stop On End Screw

INSIDE / The guts of a typical dish mover (actuator)

the numbers change on the screen. As the dish jack screw moves the dish, the feedback generator built into the jack screw sends data back to the receiver and the display numbers change as the dish moves.

It is up to the viewer to stop the dish movement when the counter says the dish is now pointing at the intended (new) satellite.

The next step up in controllers will store into memory the count-number (feedback data) for each satellite of interest. Now the user pushes a button that says "Optus B1" or "PanAmSat 2" and the microprocessor extracts from memory the count number of the chosen satellite, calculates whether the number is less than or

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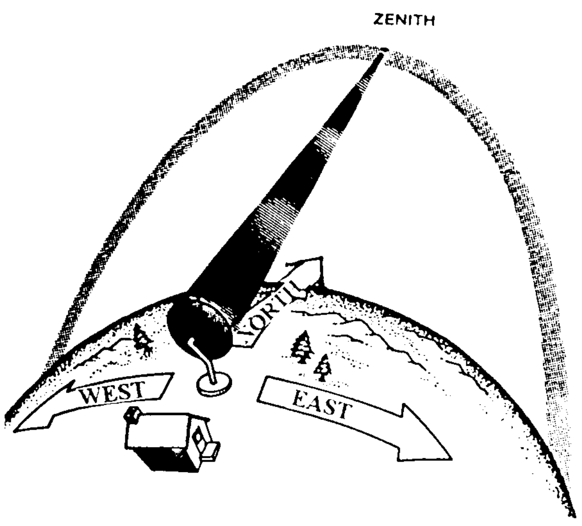
2/ **COOP'S TECHNOLOGY DIGEST** is published ten times per year, typically 40 pages, and sent fast post. A one year subscription is NZ$250.

more than the present satellite location, and instructs the jack screw accordingly. The viewer only selects the desired satellite; the smart-controller does the rest.

Some higher priced receivers combine dish moving and channel (satellite transponder) selection into the memory bank. Now the viewer becomes even less aware of the mechanics, selecting perhaps 'Australia ABC' on the receiver or remote button. This causes the receiver microprocessor to ask "*What satellite is currently in view, which channel is currently in use?*" After the microprocessor has calculated the differences in jack screw motor count for the new satellite and the held-in-memory receiver channelling information the dish starts to move while the receiver automatically tracks (moves) to the new channel. All of this is invisible to the consumer/viewer who equates this to simply changing channels. In a suitable microprocessor controlled receiver, the LNB probe polarisation is also automatically 'reset' from data stored in memory.

So to move the dish, to this point, we must have a dish mover and a dish controller. There is more.

A dish that will remain essentially 'fixed' (once installed) in azimuth and elevation presents only minor technical (design) problems to the builder. For example, consider a dish that is 1.2 metres in size, sits upon an 'L' shaped bracket attached to the side of a home. Assuming the chosen wall of the home is north facing, the dish will need to pivot on the mount over a limited range of only +/- 5 degrees (azimuth) to be usable at any location in New Zealand. For elevation, a dish used only on PanAmSat 2 will require 'yawing' (going up and down in look angle) over a range of +/- 6 degrees within New Zealand (pages 33,34).



CLARKE ORBIT ARC as it appears to you

A dish that must move (whether manually or by motor drive) from satellite to satellite requires a new set of mechanics. A bit of geometry is involved.

The Clarke Orbit belt is an imaginary but well mapped 'track in space' where satellites reside if they are to maintain their near-equilibrium over time. The belt is graphically represented as an 'arc' or curved line in the sky to our north that reaches its greatest height above the horizon due north of your location. Towards the eastern and western horizons, the arc gradually becomes lower and lower until it meets the horizon at some point that is roughly west north-west of you and east north-east.

If you set out to design a satellite dish mount to hold the antenna upright but pointing (with some adjustments possible) at only one spot in the sky, that is one challenge. If, on the other hand, the mount must allow the dish's "boresight" (direction of pointing) to follow or track the curving Clarke Orbit Belt arc in the sky, this is a quite different mechanical challenge. An earth bound telescope that tracks a particular star or star-cluster faces a very similar problem.

An arc-tracking mount is known by various names including 'horizon-to-horizon' and 'polar mount,' and these mounts mimic the Clarke

Orbit Belt as the dish is moved from the highest elevation satellite (at or near due-north from you) to those lower and lower to the horizon towards the east and west. The solution to 'perfect tracking' is a challenge and several generations of home dish systems in North America and Europe were required to 'get it right.'

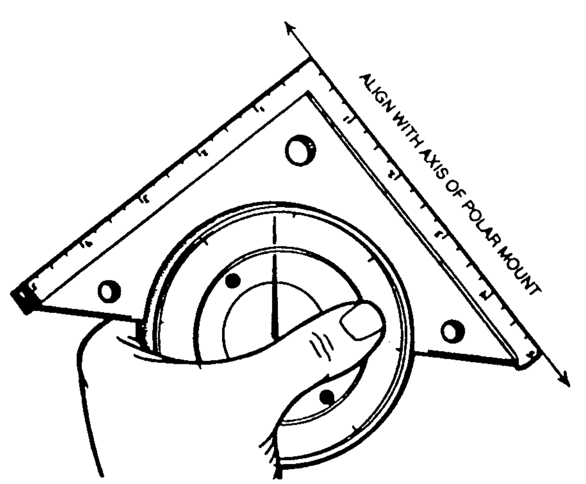
Here are the basics:

1) Knowing true north (corrected for magnetic deviation) is the first step for a location.

2) The polar mount is adjusted at the time of installation for something called 'declination,' a one time correction factor that literally 'tilts' the dish on the mount a rather precise amount to compensate for the receive terminal's latitudinal location.

3) The pivotal axis of the mount must be aligned rather carefully to true north by south. The dish 'rotates' (moves) around this axis in tracking but the axis itself maintains a magnetically corrected north-south position.

4) All dish mounts have an adjustment to set the initial 'inclination' or amount above the (flat earth) horizon (to the north) that the dish points; i.e., how many degrees 'up?'. With the dish pointed true north, and using an inclinometer (angle finder) you adjust the inclination / elevation such that the dish has an 'up angle' that corresponds to a previously calculated angle for the location (see charts here, pages 33 and 34).

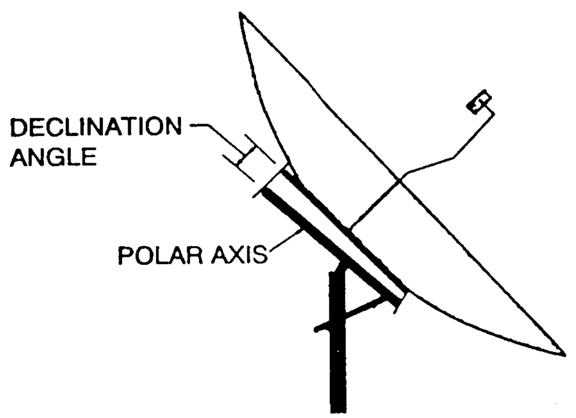


INCLINOMETER is angle finder; if it has two scales, use the edge appearing below '0' mark on scale

An angle finder is a carpenter's type device which has a flat surface (see illustration) which you lay against a flat (typically rear of dish or mount) surface on the dish that corresponds to the dish inclination angle. The dish adjustments are made until the calculated angle (such as 39.4 degrees for Hastings) is read on the angle finder.

5) With the initial inclination angle set after the mount has been declination-corrected, the dish will come very close to tracking the Clarke Orbit Belt towards the east and west horizons.

Simply put, the dish will move west or east under manual or motor control while steadily pointing closer and closer to the horizon (lower and lower) as you go further from due-north.



DECLINATION is an 'offset' that tips the dish **top** away from the polar axis arm.

There are opportunities for error here. The most common mistake is to improperly set the declination adjustment. When this happens the dish may, for example, track satellites either side of due north (due north in the satellite field is always referenced as 0 degrees, and is always true north as corrected for magnetic declination), but, will gradually depart from the Clarke Orbit Belt as you move the dish further and further towards the horizons, or to due north. This is illustrated.

LOCATION	POLAR AXIS DECLINATION
KAITAIA	5.65 degrees
AUCKLAND	5.84 degrees
HASTINGS	6.19 degrees
WELLINGTON	6.40 degrees
GREYMOUTH	6.52 degrees
CHRISTCHURCH	6.64 degrees
DUNEDIN	6.87 degrees

Offset angle for dish hub-flat-surface from polar axis; courtesy **Nigel Clough**, Waikanae

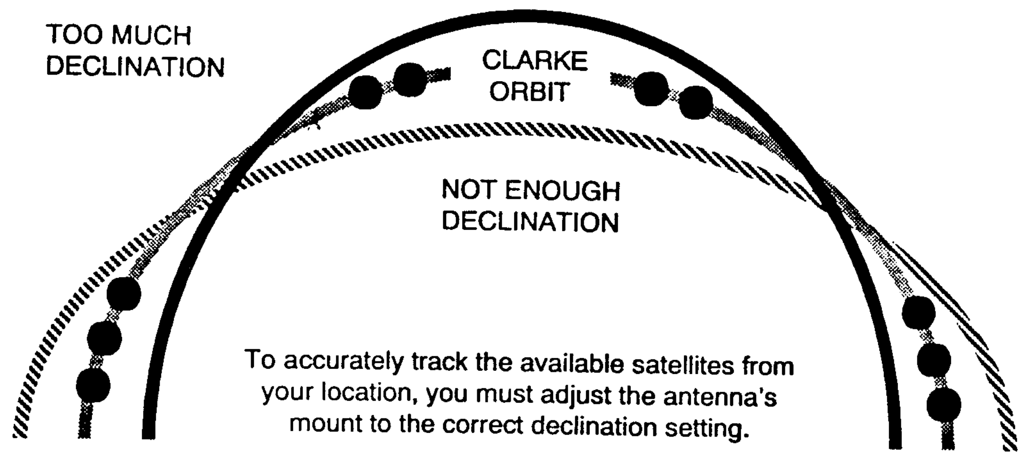
Some mounts sold do not provide for declination offset. Avoid such mounts if you will be using the antenna system for Clarke Orbit Belt tracking. The declination offset will be essentially the 'same' (i.e., same amount of adjustment) for a fairly sizeable area of the country. As an example, from Wellington to Hastings and east-west across North Island will require essentially the same offset adjustment (+/- 0.1 degrees). This means that when installing dishes in the same geographic area once you have declination offset mastered for your area, you will simply repeat the process with each dish installed without much thought.

Dishes accomplish declination offset mechanically; usually using 'shims' or metal washers to allow the installer to 'tilt' or 'tip' the dish on the mount by a few degrees in either direction. As the dish is assembled, you install (or leave out) shims or washers to achieve the required declination offset your area requires as the dish goes onto the mount. The amount of declination (offset) can be measured to typically 0.5 degrees with an inclinometer by comparing the polar axis setting (see tables, pages 33 and 34 here) to the declination measurement point to achieve the offset shown to left for your region.

DISH POWERING

If the dish is equipped with a motor drive, it requires operating voltage as well as position sensors. Most actuators operate from 24 to 36 volts dc and power for this comes from either the dish controller or the receiver if it is equipped for this function.

Position sensing is done with a system similar to the rotational sensor in the feed probe. This requires three wires, one of which is the wrap around shield. Another is a dedicated ground and the third is the feedback transmission wire. As the jack screw motor operates and the movement arm lengthens or shortens, there is a feedback loop from the actuator arm to the controller. The actual data can come from a ten-turn precision pot that translates the actuator extension to pot resistance, or, some form of Hall Effect or other (pulse) generator installed



MIS-SETTING the declination offset will result in Clarke Orbit Belt tracking errors; corrections suggested here.

on the actuator. The 'feedback' is interpreted by a microprocessor in the controller / receiver and produces a display for the user that relates where the dish is pointed. For the same reason shielded wire is important for the feed probe pulse transmission, only shielded wire is used for the actuator feedback circuit.

The dish movement jack screw is typically equipped with 'end of arm' limits to make it less likely (impossible is another word) the user will in error drive the jack screw off at its extended end, or try to 'ram' the jackscrew in after it has already reached minimum length.

Most actuator arm feedback systems are reasonably insensitive to long line runs but the DC operated motor line is subject to the usual 'IR' losses found in any DC powering system; long line lengths require larger diameter powering wires (a typical actuator draws from 3 to 6 amps DC).

C-BAND or Ku?

The Pacific Ocean Region, to this point, has received limited C-band satellite coverage from Global beaming Intelsat satellites. New satellites coming on line over the next 36 months will be both C and Ku. Australian Aussat (and the replacement Optus) satellites are limited to Ku-band.

North American satellites began as C only but Ku has in the past 12 months become increasingly the 'band of choice.' European satellites have concentrated on Ku services.

Between the two, Ku-band offers the advantage of smaller receiving antennas (generally 1/3rd the physical size of C), and in production quantities, slightly less expensive electronics. For the satellite operator, Ku beams can be 'focused' more precisely than at C, creating the opportunity to fashion transmission coverage for just a single country (Japan is an example).

New satellites coming on line for the Pacific Ocean Region have both bands on board and the choice between C and Ku is largely made by **(a)** the availability of transponders for lease (to programmers), **(b)** the cost of the transponders (CTD: 9405, p.2), and, **(c)** the intended viewing audience. Programming services created for direct viewing by an audience that will have to make a purchase decision for a dish system usually opts for Ku band since the cost of Ku band <u>home</u> systems can be as low as 1/3rd the cost of similar C-band systems. By selecting Ku-band, the programmer knows it will attract more viewing homes, sooner, because the cost to the viewer is lower, and, the dishes smaller.

C-band dishes are generally 'perforated mesh' although solid aluminium and fibre glass (equipped with a reflective material since fibre glass by itself is transparent to radio signals) are still offered. Perforated mesh surfaces 'worry' some newcomers to the satellite field. The answer is that perforation holes in the metal surface do not allow satellite (microwave) signals to 'slip through' provided the hole dimensions are kept under 2.1mm at Ku, 6.4mm at C.

The 'best' reflector surface is a solid piece of lightweight, strong, but pliable metal. Aluminium is an example. The next best reflector surface is anything of the proper shape and curve which will reflect microwave signals. Fibre glass dishes reflect only because they have a reflective surface added; either metal 'screening' sandwiched inside of the fibre glass form or a spray-on zinc or similar reflective coating. A piece of metal, with holes punched in it, will be 99% as efficient as a solid piece of metal provided the maximum hole size does not exceed approximately 1/12th of a wavelength at the operating frequency. At 12,000 MHz, a wavelength is 25mm long and 1/12th of that is 2.1mm. At C-band, the holes can be up to 6.4mm maximum size (holes can be round, oblong, even square, provided their longest dimension does not exceed the dimensions given).

Punching holes in metal does several desirable things to the antenna, including:

a) 'Opens it up' so the wind pressure is reduced;

b) Allows some of the moisture striking the dish in a driving rain to 'blow through', reducing the 'load' on the antenna;

c) Makes the antenna at least partially 'transparent' since the openings from a distance make it seem more like a screen than a solid surface;

d) Reduces the weight of the antenna by the amount of metal 'punched out.'

DISH MISTAKES

The dish has a 'parabolic' shape. The parabola is a geometric design which a modern dictionary describes:

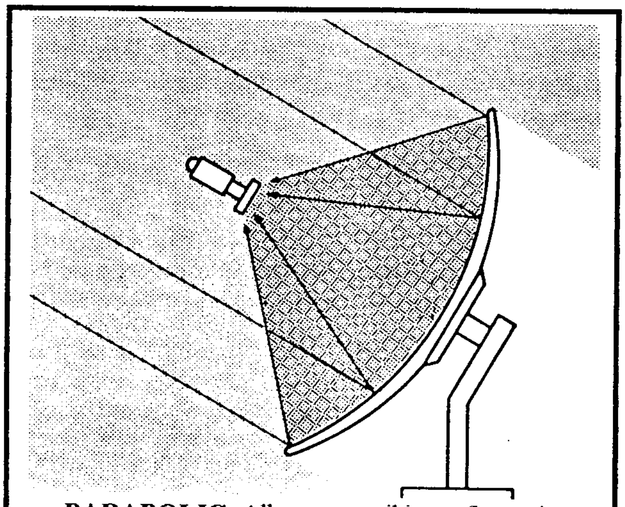
"An open plane curve formed by the intersection of a cone with a plane parallel to its side."

In plain English:

"Each point on the parabola's surface is equidistant from an imaginary point at the centre of the parabola."

In even plainer English:

The satellite is a source for radio wave signals. The signals travel some 40,000 km or so to the (parabolic shaped) dish 'antenna.' The 'dish' is a reflector; the satellite signal it intercepts is stopped by the metallic or reflective qualities of the dish, turned around, and "focused" to a single point.



PARABOLIC: All energy striking reflector is refocused to 'central' (feed) point

The curved surface creates the focusing effect. The satellite signal(s) intercepted by the reflector are redirected in a new direction. At any instant in time, the reflector collected energy converges at a single focused point out in front of the reflector.

It is at this "focus point" that you place the LNB + feed antenna. The feed antenna 'looks at' (sees) the reflector as a 'spread signal source' (as opposed to a point signal source) and the gain of the antenna system results from the capture area of the reflector plus its ability to redirect the captured energy to a single, focused point.

The secret to a properly working parabolic reflector and its focus point collection ability is the accuracy of the reflector. If the physical distance from the reflector surface to the focus point is equal for all points on the reflector, the signals intercepted by the reflector arrive at the focus point 'in phase.' In other words, they 'add together.' If, on the other hand, the reflector surface is somehow distorted and signals reflecting from one portion must travel further from the reflector to the focus point than signals bouncing off of a different portion of the reflector, the focus point signals are 'out of phase.' They cancel one another.

The accuracy of the reflector surface (i.e., how true every point on the surface is to the desired parabolic shape) is a major part of the antenna's performance. Placing a properly designed 'feed antenna' at the precise focal point is the rest of the equation.

Surface accuracy is not a simple thing to 'prove' in the field. But there are a few steps you can take to approximate the accuracy.

1) Sight along the dish rim: Stand back from the dish and with your eyes focus on the furthest edge of the rim. Now move your head slightly to see if the nearest edge of the rim aligns (exactly follows) the far edge of the rim. If the two rim segments align in some spots but not in others, the dish is 'warped' (i.e., it is

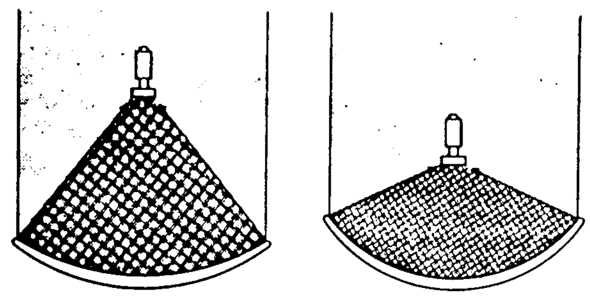
somehow twisted on its own central hub). Warped dishes occur with sectional designs that break the parabolic 'circle' into segments (such as 4 equal quarters) and then attempt to put the sections back together as a whole. Virtually all dishes larger than 2 metres in diameter are assembled in 'sections.' Depending upon the amount of 'warp' the dish may perform OK on C band (longer wavelengths, greater antenna error tolerances) but bad on Ku, or, be unsuitable for either band.

2) Focal point distance: Use a tape measure or string and measure the distance from the rim of the antenna to the focal point. Do this at least four times from 4 widely separated identical points around the edge of the dish to the focal point. The measured distance should always be the same (same: within 6mm at C band, 2mm at Ku). If it is not, the dish is not parabolic.

3) Cross hairs test: Run a string from the 12 o'clock position to the 6 o'clock position using some care to ensure the two points of string attachment are 180 degrees apart (on a 360 degree circle). Now run a second string from 3 o'clock to 9 o'clock. Where the two strings cross is the centreline for the focal point (not the actual focal point). Check now to verify that the feed is precisely behind the cross-hairs on a line that begins in the centre of the dish (the middle of the hub), passes through the cross hairs and ends up in the middle of the feed antenna assembly. This verifies the accuracy of the focal point on a working dish, or, establishes a line on which the feed antenna should fall when a dish is installed.

If the feed antenna produces maximum signal with the feed located off of this line, the dish is warped or distorted.

4) Determining the focal point for a dish: On a fully parabolic (as opposed to spherical) dish you can determine the location where the feed antenna (LNB) should go even if that information is 'missing.' The 'focal point' is a function of the 'depth of the dish'. Some dishes are known as 'deep' while others are called 'shallow'. We determine 'deep' and 'shallow' with a simple measurement. A taunt edge (string) is stretched from dish edge to dish edge (such as 3 o'clock to 9 o'clock) and using this taunt edge as a reference, measure the distance from the string to the deepest (centre) surface point of the dish. Write that number down.



Shallow (left) versus deep (right)

Now measure with some precision the diameter of the dish; from edge to edge. Many manufacturers round off dish sizes (usually upwards) and a so-called ten footer may in fact be 9'10". Write down the exact diameter.

With these two numbers we will determine the f/D of the dish: focal length to Diameter. Using the same measurement units (mm, inches), start with a 9'10" diameter dish that has a depth of 19". 9'10" is the same as 118".

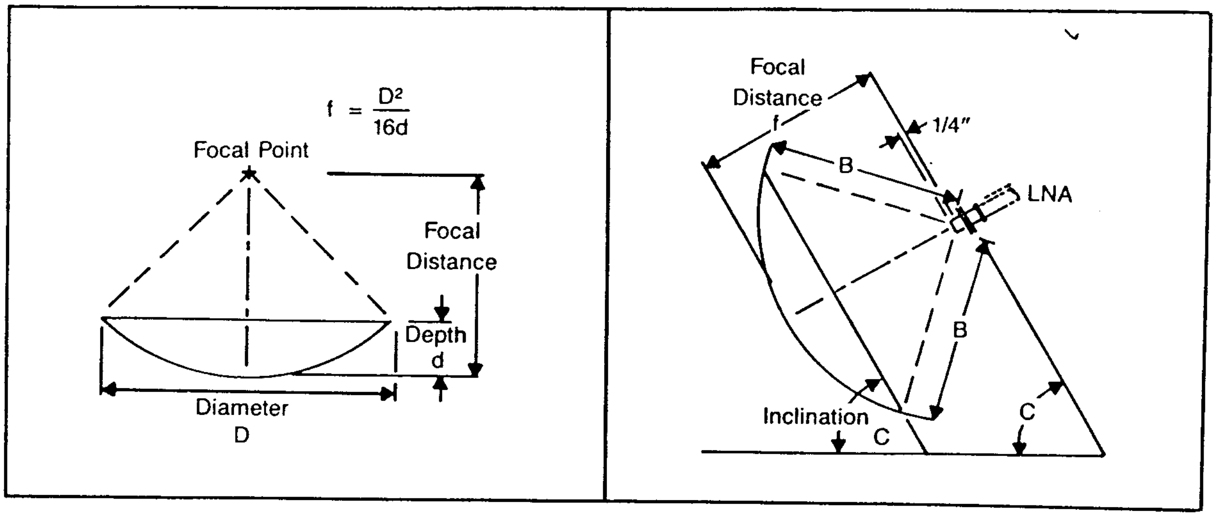
The focal point (where the feed antenna is located) formulae is:

Focal point equals diameter squared divided by 16 times the depth.

So diameter (118") squared is 13,924
16 times 19" (depth) is 304

13,924 divided by 304 is 45.8" and that is the focal point (location for the feed antenna). Now, finding the antenna f/D (ratio) requires that you divide the focal distance (45.8") by the dish diameter (118").

45.8 divided by 118 is .388 which rounds up to .39. Dish manufacturers and engineers refer to the 'f/D' when they are designing the feed



FOCAL DISTANCE and depth (left hand) are discussed in text. LNA/B/F installs at dish focal point and centres (in-out) to within 6mm when properly focused (within 6mm at C band, 2mm at Ku). Angle **C** is polar axis inclination for your location (**same as your degrees in latitude**), measured upwards from base of dish. **B** (distance from edge of dish lip to feed centre) should be equal from any point on the dish lip to dish centre.

antenna. The challenge is to create a feed antenna which 'illuminates' (sees evenly) the entire dish surface. The feed antenna has its own 'pattern' and if it 'sees' the central area of the dish better than its sees the edges, the transfer of reflected energy originating around the edges of the dish will be less efficient than the centre region. When this happens, the gain of the antenna system is degraded simply because some of the reflected energy is lost by the inability of the feed antenna to capture ('see') it.

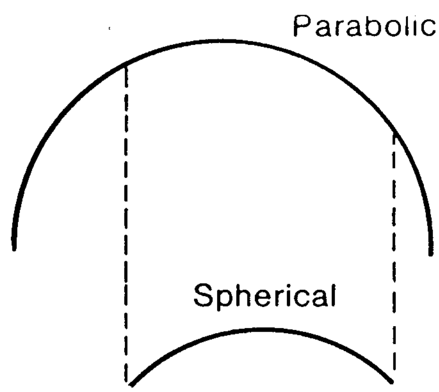
The important point here is that not all feeds work well with all dishes. Some feeds are designed to work best with deep dishes (typically f/D ratios of .3 or less) while other feeds work best with 'shallow dishes' (f/Ds larger than .35) A reputable antenna manufacturer will specify either a specific feed, or, category of feed for his dish. Lacking that information, you can calculate whether you need a 'deep dish feed' or 'shallow dish feed' based upon the mathematical exercise just outlined. Selecting the wrong feed can cost you 2dB of signal or more; the difference, for example, between a 6 dB CNR and an 8 dB CNR.

NOT A PARABOLA

A parabola is a complete geometric form. It turns out that for our antenna purposes you can achieve the gain of a parabola by using only a section of the full geometric form; provided the size of the segment is suitably large.

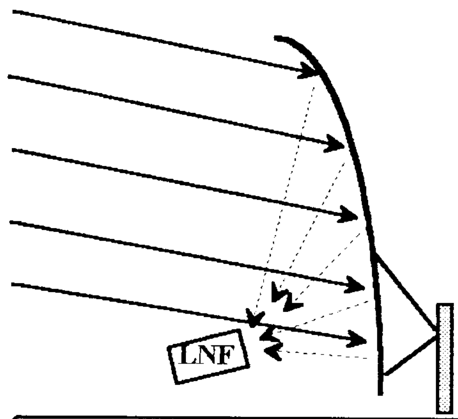
These 'segment-of-parabola' antennas are called by many names; spherical is one of these names. Commercially, manufacturers often call these segment-of-parabola antennas 'Offsets.'

As illustrated here, a segment of a parabola has the shape geometry of a parabola, only it is but a portion of the full parabola. This changes



OFFSETS are spherical in shape, segment of parabola the location of the focus point significantly, and that's not all bad. Rather than focusing to the centre, the spherical focuses to an off-centre position. In most commercial offset antennas the focus point has been designed to appear at or near the base or bottom of the antenna. Looking at the diagram here, you can visualise why this happens.

SPHERICAL: PARABOLA SECTION



OFFSET/spherical uses segment of parabola. By selecting 'top' portion, feed mounts low on antenna and often closer to mount and installer

Offset antennas are very popular for Ku band purposes because with physically smaller antennas they make it possible to position the LNB + feed antenna down near the bottom of the structure. This makes it far more convenient for the installer to install, work on, and 'peak' the antenna since the electronics and feed are situated close to the base of the 'array.'

Offset antenna gain is virtually identical to full parabola antenna gain provided the square area of the reflector surface is identical between the two comparison antennas. Thus by selecting an offset Ku antenna, you are not sacrificing antenna gain in the process.

During the past 18 months, entirely new materials have entered the shaped reflector business. One of the most innovative is ABS-Polymer; a variant of plastic. Plastic, of course, is transparent to radio frequency waves so like fibre glass dishes, a reflective material or coating must be applied. As Nigel Clough (29 Matai St., Waikanae: 04-293-2058) notes:

"ABS-Polymer is an amazing material. When sheets are heated to about 200 degrees C they assume a pliable state and are readily vacuum moulded into very complex shapes with very high accuracy. On cooling they retain that shape without unpredictable shrinkage and what is more this shape becomes 'memorised' so that upon being deformed by force it wishes to return to its memorised shape. You end up with a non corroding highly resilient product at low cost."

Dishes of ABS-Polymer are now market leaders in European Ku DBS applications and the size range being done (below 1m to 1.5m) rather precisely fits our likely PAS-2 and other Ku band home DBS antenna requirements. Equally important, the specialised computer derived 'shaped reflectors' that produce enhanced gain when married to suitable feeds are more easily created with ABS-Polymer than most metal or fibreglass techniques.

'Shaped reflectors' can be straight forward sphericals, or they can be some computer modelled variation of the true spherical. Recent shaped parabola's have become 'flatter and flatter' (approaching totally flat) as the technology surrounding the design of feed antennas has matured. Think of a 'shaped reflector' as nothing more complicated than it being a 'segment of a segment;' i.e., the spherical is a segment of a full parabola, while a shaped antenna is a segment of a spherical. Each time the antenna designer selects a smaller segment of the original segment, the amount of reflector curve is reduced (in both directions) so the surface becomes closer and closer to a flat surface. As long as the feed antenna design is modified to 'illuminate' these flatter and flatter segments, the system gets better and better (from the viewpoint of ease of manufacture, ease of shipping plus installation).

Totally flat antennas deserve a mention. They are designed following 'Fresnel Lens' theory and their present state allows gains of (a claimed)

43.4 dB for a 1.5 metre 'flat plate' at Ku. The beauty of a flat plate antenna is that it can be mounted flushly against a north-facing exterior wall with no complicated mounting hardware. Today, the technology is only in prototype form, the costs are unknown, and the demonstrations of performance have been done only by the antenna's developers: Flat Antenna Company, Stansted, Essex.

Selection of a proper feed for a spherical or 'shaped' reflector becomes very important to performance. Old fashioned parabola feeds were designed to illuminate a full circle of reflector surface; spherical feeds designed to illuminate a segment of a parabola (typically taller than they are wide) while a 'shaped segment' requires yet a third feed illumination design.

Bottom line? You select the proper feed based upon the reflector design. And if you select the wrong feed, you will be tossing away several very important dBs of gain.

WEATHERPROOFING

Terrestrial TV antenna installers have learned the benefits of using a few pence of weather proofing sealant at the time of installation.

A modern DBS / DTH home installation has but one RF-sensitive cable exposed; the RG6 family of cable (with 'F' series connector) that plugs into the rear of the LNB/F and carries the IF signal indoors. First of all, two piece 'F' series connectors are out: Only use those rated for outdoor use, with an integral crimp or 'O' ring attached. The outdoor rated connectors provide either a rubber boot that pulls down over the fitting, or a rubber sealing 'gasket' that goes onto the fitting just before crimping. Even the slightest amount of moisture in a 1 to 2 GHz fitting will shut you down. Taping over the fitting in lieu of properly protecting it is a bad mistake as moisture condenses inside of the tape and leaks into the fitting.

Power and sensor connections for an actuator, the LNB probe or other functions should be sealed with a silicone sealant. All cables should be 'tie-wrapped' to the base of the mount and if you are using a motor driven actuator assembly, remember to leave a 'turning loop' in the cable(s) to allow rotation through the turning radius.

True parabolic dishes have the feeds pointing 'down' (because of the dish inclination angle) so moisture can not 'drop in.' However spiders and other insects (especially wasps) love the nice, snug interior of the feed and you may need to cover the feed over with a fine plastic mesh. Don't seal the feed opening entirely; that allows moisture to condense (the LNB will run warmer than the surrounding air). The fine plastic netting must be plastic; no metallic strings in it because they will attenuate the C or Ku waves. Offset dishes often have feed openings that are pointed slightly upward when correctly aligned. This invites moisture inside and in areas where it snows, snow will fill up the feed.

Snow or ice on the surface of a dish (whether parabolic or spherical) will cost you signal; more so at Ku than at C. Your customers should be advised to take a broom and sweep it off if they can reach the installation. The alternative is to lose signal to the moisture in the snow / ice until the weather warms up.

FEED BUILT-IN

The earliest dish systems required assembly of an LNA (low noise amplifier) and feed at the focal point. The down converter that changed the 3.7-4.2 GHz energy to an IF was done at the receiver and the LNA powered the C band energy through large diameter, low loss coax inside to the receiver.

This was superseded by LNBs; a combination low noise amplifier(LNA) and down converter which was then married to the separate feed antenna system. The inward bound signal was now at IF as it left the dish feed area rather than at C band and smaller diameter, higher loss cables became the norm.

More recently, the LNB has become an LNBF or LNF; low noise block down converter with feed built in. At this point the installer deals with one source for a single part that includes all of the feed, polarisation switching, low noise amplification and block down conversion hardware.

This reduces the number of parts the installer must inventory, simplifies the wiring of the feed electronics to the receiver, and reduces costs rather dramatically.

ALL OF THIS SAYS...

Although Ku band equipment began as simply C band equipment reduced in size by 1/3rd from C band, the sizeable number of Ku band systems sold has brought forward innovative engineering which has yet to be duplicated at C band. In many cases, such as the shaped spherical reflectors, the difference in frequency (C band wavelengths being three times as long as Ku band) will stop the Ku innovations from becoming important at C.

THE ADDRESSABLE INTERFACE

The original C and Ku receivers were designed to receive television transmissions in one or more transmission formats; PAL, NTSC or SECAM. Changes occurred as the transmission parameters matured.

When a satellite transponder was 36 MHz 'wide' and carried only a single TV programme channel, the receivers were designed to this 'standard.' When it became practical to fit a pair of television programme transmissions into a 36 MHz wide channel (each occupying approximately 18 MHz of 'space'), the receiver designs upgraded to allow some form of user adjustable bandwidth; a switch, or a 'continuous bandwidth change' control.

With the advent of 54 MHz wide (Ku) transponders, receiver designs changed again. Although it was always possible to use the full 54 MHz bandwidth for transmission of a single TV programme, this was not cost effective. So European Ku band birds with 54 MHz wide transponders carry a pair of 27 MHz wide video signals; half of the transponder to each programme channel. Once again, receiver designs had to change to allow the user to select either the 'lower half' or the 'upper half' of the transponder.

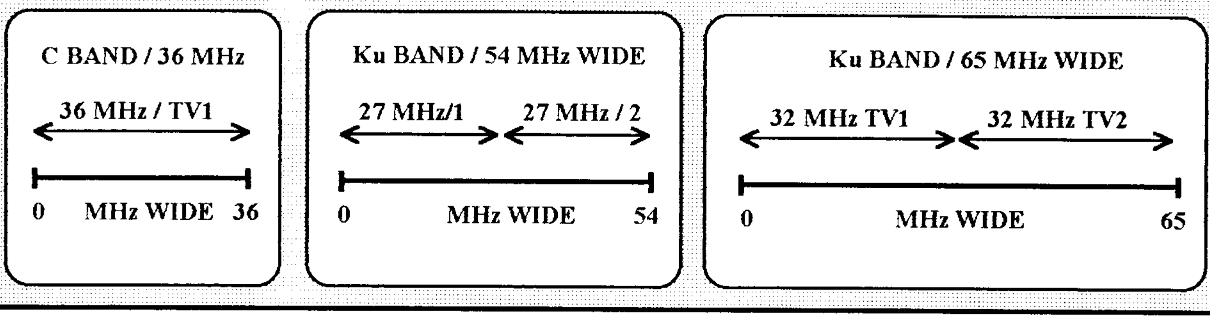
Here in the Pacific, PanAmSat PAS-2 has both C and Ku transponders. In the C portion 4 are 64 MHz wide while 12 are 36 MHz wide. In actual use, the 64 MHz wide transponders will (if they carry video) be split in lower and upper halves of 32 MHz each. The 36 MHz wide C band transponders are likely to be used at full width (36 MHz) for a single analogue programme each.

The Ku band portion of PAS-2 has 4 transponders with 65 MHz width and 12 transponders with 54 MHz width. The 65 MHz bandwidth transponders may see very little use for analogue video; for digital video one 65 MHz wide transponder could provide as many as 7 'broadcast quality' programme service channels, or as many as 14 'cable quality' programme channels. The 54 MHz wide transponders can provide a pair of analogue programming channels, each, from day-one or up to 6 broadcast quality digital / 12 cable quality digital.

For analogue reception, the receiver's IF bandwidth must match the satellite's transmitted bandwidth. The range, then, is from a minimum of 22 MHz wide (65 divided by 3) to a maximum of 36 MHz wide. The most common analogue bandwidth at C is likely to be 36 MHz; at Ku, 27 MHz.

The basic satellite receiver does not really care whether the incoming signal originates at C or Ku since the input frequency range on the receiver is in the 900 / 950 to 1400 / 1450 (up to 2100) MHz range. The LNB (LNF et al) determines the actual frequency range sent to the receiver and the incoming range to the LNB is chosen by selecting whether you wish C or Ku reception. At this stage of technology, C and Ku require separate LNBs and may require separate feeds. Thus even if the same dish (reflector surface) is used for both bands, and the same receiver is used for both bands, in between these two points there must be a single

HOW SATELLITE TRANSPONDERS ARE 'DIVIDED' FOR ANALOGUE TV



band LNB and probably two single band feed antennas.

None of this focuses on the addressability of each receiver. Our experience with 'electronic addressing' to date has been limited to the SKY Network News Datacom Videocrypt 'card authorisation system' (see **Coop's Technology Digest**: issue 9404, p.29; 9405, p.29; 9407, p.38). The concept is dead-simple. Programmers earn money by selling programming. Authorised viewers pay a fee and by some electronic technique the authorised viewer's decoder is turned on when money has been paid, turned off when it has not been paid. The addressing systems in use can turn on specific receivers for specific channels for specific periods of time.

Videocrypt functions by providing authorised viewers with a plastic card that is filled with sub-miniature electronics. The card has an addressable 'number' unique to that card. The viewer has a decoder box provided by the programmer which is capable of descrambling (decoding) the scrambled transmissions when the box is 'unlocked' with a special 'key.' The plastic electronic authorisation card contains the 'key' but this 'key' is further protected with the electronic equivalent of a combination lock tumbler.

To 'unlock' the 'key' the decoder box requires a set of numbers. These numbers are transmitted by SKY within its programme material. Each authorised card, when inserted into the decoder box, becomes a part of the electronic circuit of the decoder box. The authorisation card has a part of the numbers permanently in memory; the rest of the 'combination' is transmitted to the decoder, is routed through the memory of the authorisation card, and when 'numbers match' between the transmitted instructions and the card's permanent memory instructions, the combination lock opens, the key turns on the decoder and the viewer has pictures.

The ability to 'address' each subscriber is basic to subscription television operation. Thus it is no surprise that receiver manufacturers now offer receivers with the same basic design features of the SKY decoder box built into the receiver proper.

The only item missing at this point is the authorisation card.

So just as the original low noise amplifier (LNA) grew into an LNB and then to an LNF, the receiver which began life as a simple IF strip covering 900-1400 MHz has developed into a microprocessor based dish controller with polarisation, bandwidth and audio parameters for each channel 'in memory', plus it has added the basic addressable functions as well.

There is an unknown element, however, for New Zealand installers.

As of early in July (1994) the exact encoding scheme to be employed by DTH programmers has not been announced. This is ultimately an

-SATELLITE 'LOOK-ANGLES' FROM NEW ZEALAND-

Base data, computations courtesy Nigel C. Clough, 29 Matai St., Waikanae / 04-293-2058

SITE	NORTH ISLAND			KAITAIA		AKLND		WLGTN	
LONG.				173.18E		174.47E		174.47E	
LAT.				35.08S		36.55S		41.17S	
Polar Dec				5.65 deg.		5.84 deg.		6.40 deg.	
SAT	**Location**	**BAND**	**Pol.**	**EL**	**True Az.**	**EL**	**True Az.**	**EL**	**True Az.**
Stat.14	**96.5E**	**C**	**Linear**	**2.18**	**277.75**	**0.94**	**277.23**	**0.33**	**277.99**
Asiasat 2	100.5E	C	Linear	5.44	280.16	2.07	278.98	3.31	280.71
Stat.21	**102.7E**	**C**	**CP**	**7.24**	**281.53**	**4.75**	**280.71**	**4.95**	**282.25**
Asiasat 1	**105.5E**	**C**	**Linear**	**9.53**	**283.28**	**8.15**	**282.91**	**7.04**	**284.21**
Palap2R	**108.0E**	**C**	**Linear**	**11.57**	**284.89**	**10.15**	**284.54**	**8.91**	**285.99**
PalapC1	113.0E	C	Linear	15.64	288.23	14.13	287.94	12.58	289.69
PalapaB4	**118.0E**	**C**	**Linear**	**19.67**	**291.79**	**18.08**	**291.54**	**16.22**	**293.57**
Raduga27	128.5E	C	CP	27.91	300.15	26.12	299.91	23.73	302.49
Rimsat(1)	130.0E	C/Ku	CP	29.04	301.49	27.25	301.24	24.59	303.85
ApStar1	131.0E	C	Linear	29.79	302.39	27.99	302.14	25.25	304.78
Goriz.17	**134.3E**	**C/Ku**	**CP**	**32.11**	**305.41**	**30.27**	**305.02**	**27.31**	**307.79**
Stat.7	139.9E	C/Ku	CP	36.22	311.31	34.29	310.93	30.88	313.78
Rimsat(2)	142.5E	C/Ku	CP	37.88	314.09	35.93	313.66	32.35	316.53
OptusA3	**156.0E**	**Ku**	**Linear**	**45.33**	**331.72**	**43.32**	**330.71**	**38.79**	**333.11**
Optus B1	**160.0E**	**Ku**	**Linear**	**46.89**	**337.83**	**44.92**	**336.57**	**40.16**	**338.59**
Coupon3	162.0E	C/Ku	CP	47.54	341.02	45.49	339.63	40.73	341.43
Optus A2	**164.0E**	**Ku**	**Linear**	**48.09**	**344.29**	**46.17**	**342.76**	**41.22**	**344.32**
PanAm2	169.0E	C/Ku	Linear	49.01	352.75	47.21	350.87	42.09	351.72
Rimsat(3)	170.75E	C/Ku	CP	49.23	357.51	47.51	355.44	42.33	355.85
Intel701	**174.0E**	**C/Ku**	**CP**	**49.25**	**1.43**	**47.59**	**359.21**	**42.42**	**359.29**
Intel511	**177.0E**	**C/Ku**	**CP, LP**	**49.05**	**6.63**	**47.51**	**4.24**	**42.35**	**3.84**
Intel508	**180.0E**	**C/Ku**	**CP, LP**	**48.61**	**11.76**	**47.19**	**9.23**	**42.08**	**8.37**
Intel503	**177.0W**	**C/Ku**	**CP, LP**	**47.93**	**16.76**	**46.64**	**14.14**	**41.62**	**12.84**
SatcmC5	139.0W	C	Linear	25.49	62.49	25.72	60.55	23.21	58.03
SatcmC1	**137.0W**	**C**	**Linear**	**23.92**	**64.11**	**24.21**	**62.24**	**21.83**	**59.81**
SatcmC4	135.0W	C	Linear	22.35	65.68	22.69	63.88	20.44	61.54
GlxyG1	**133.0W**	**C**	**Linear**	**20.76**	**67.21**	**21.15**	**65.46**	**19.04**	**63.23**
SatcmC3	**131.0W**	**C**	**Linear**	**19.16**	**68.68**	**19.59**	**67.01**	**17.61**	**64.87**
GlxyG5	**125.0W**	**C**	**Linear**	**14.31**	**72.89**	**14.88**	**71.41**	**13.27**	**69.61**
SpNetS1	**120.0W**	**C**	**Linear**	**10.23**	**76.17**	**10.89**	**74.84**	**9.59**	**73.32**
Morelos2	116.0W	C	Linear	6.96	78.69	7.71	77.47	6.62	76.19

-SATELLITE 'LOOK-ANGLES' FROM NEW ZEALAND-

Base data, computations courtesy Nigel C. Clough, 29 Matai St., Waikanae / 04-293-2058

SITE	SOUTH ISLAND			GRYMH		CHCH		DNDIN	
LONG				171.12		172.4		170.3	
LAT				42.28		43.33		45.52	
Polar Dec				6.52		6.4		6.87	
SAT	**Location**	**BAND**	**Pol.**	**EL**	**True Az.**	**EL**	**True Az.**	**EL**	**True Az.**
Stat.14	**96.5E**	**C**	**Linear**	**2.63**	**280.48**	**1.51**	**279.78**	**2.58**	**281.71**
AsiaSat2	100.5E	C	Linear	5.56	283.31	4.39	282.64	5.34	284.71
Stat.21	**102.7E**	**C**	**CP**	**7.16**	**284.91**	**5.97**	**284.26**	**6.85**	**286.39**
AsiaSat1	**105.5E**	**C**	**Linear**	**9.21**	**286.96**	**7.97**	**286.31**	**8.76**	**288.56**
Palap2R	**108.0E**	**C**	**Linear**	**11.01**	**288.83**	**9.75**	**288.2**	**10.46**	**290.56**
PalapC1	113.0E	C	Linear	14.59	292.71	13.27	292.09	13.8	294.61
PalapB4	**118.0E**	**C**	**Linear**	**18.11**	**296.78**	**16.73**	**296.16**	**17.06**	**298.87**
Raduga27	128.5E	C	CP	24.9	305.99	23.43	305.42	23.33	308.5
Rimsat(1)	130.0E	C/Ku	CP	26.07	307.62	24.59	306.92	24.38	310.07
ApStar1	131.0E	C	Linear	26.69	308.61	25.21	307.91	24.95	311.08
Goriz.17	**134.3E**	**C/Ku**	**CP**	**28.58**	**311.83**	**27.21**	**307.85**	**26.71**	**314.37**
Stat.7	139.9E	C/Ku	CP	31.88	318.02	30.35	317.14	29.63	320.58
Rimsat(2)	142.5E	C/Ku	CP	33.23	320.95	31.71	320.04	30.84	323.54
OptusA3	**156.0E**	**Ku**	**Linear**	**38.82**	**338.12**	**37.35**	**336.79**	**35.71**	**340.34**
OptusB2	**160.0E**	**Ku**	**Linear**	**39.89**	**343.71**	**38.47**	**342.23**	**36.61**	**345.71**
Coupon3	162.0E	C/Ku	CP	40.31	346.58	38.92	345.03	36.95	348.44
OptusA2	**164.0E**	**Ku**	**Linear**	**40.65**	**349.48**	**39.31**	**347.86**	**37.23**	**351.21**
PanAm2	169.0E	C/Ku	Linear	41.14	356.85	39.91	355.05	37.58	358.18
Rimsat(3)	170.75E	C/Ku	CP	41.21	0.51	40.05	358.73	37.57	1.69
Intel701	**174.0E**	**C/Ku**	**CP**	**41.11**	**4.28**	**39.99**	**2.33**	**37.47**	**5.18**
Intel511	**177.0E**	**C/Ku**	**CP, LP**	**40.82**	**8.71**	**39.81**	**6.69**	**37.18**	**9.35**
Intel508	**180.0E**	**C/Ku**	**CP, LP**	**40.35**	**13.07**	**39.43**	**11.01**	**36.72**	**13.47**
Intel503	**177.0W**	**C/Ku**	**CP, LP**	**39.71**	**17.36**	**38.88**	**15.26**	**36.11**	**17.53**
SatcmC5	139.0W	C	Linear	20.32	60.45	20.62	58.83	18.08	59.72
SatcmC1	**137.0W**	**C**	**Linear**	**18.95**	**62.17**	**19.29**	**60.59**	**16.81**	**61.47**
SatCmC4	135.0W	C	Linear	17.57	63.85	17.95	62.32	15.51	63.21
GlxyG1	**133.0W**	**C**	**Linear**	**16.17**	**65.51**	**16.59**	**64.01**	**14.19**	**64.89**
SatcmC3	**131.0W**	**C**	**Linear**	**14.76**	**67.11**	**15.21**	**65.65**	**12.87**	**66.55**
GlxyG5	**125.0W**	**C**	**Linear**	**10.46**	**71.74**	**11.02**	**70.42**	**8.83**	**71.36**
SpNetS1	**120.0W**	**C**	**Linear**	**6.83**	**75.43**	**7.47**	**74.21**	**5.41**	**75.22**
Morelos2	116.0W	C	Linear	3.91	78.29	4.61	77.14	2.65	78.21

important decision since there are at least four widely used encoding formats in the world and each is sufficiently unique that a receiver designed for one of these formats will not function with any of the other three. Therefore, to select receivers for sale in New Zealand the installer has to be certain the decoding portion of the receiver will suit the encoding format used by the programmer(s). Manufacturers designate receivers which either come equipped with decoders, or which have been designed to allow a modular decoder to be installed inside of the receiver at a later date as an 'IRD;' integrated receiver descrambler.

As a practical matter, receivers without any decoding ability can be adapted with outboard decoders after the fact. In Europe where three separate encoding schemes are in use, some satellite viewers have one receiver and three separate decoders: one for each format(!). There is nothing desirable about having three separate decoders stacked up on top of the television set, but it is an option none the less.

REPRESENTING THE PROGRAMMERS

SKY Network terrestrial distribution contracts out subscriber installations to installation companies. However, any dealer may install a SKY system and in fringe areas non-appointed-by-SKY installers conduct the majority of the installation basis. Whether SKY will become a part of the satellite DTH marketplace is conjecture only at this point (see **CTD:** 9407, p.27). On the assumption SKY does become a satellite-direct programming service, it is probable the firm will follow the terrestrial service procedure and appoint installing contractors in geographic regions.

Whether 'SKY Satellite Direct' happens or not, there will be other DTH programmers on satellite. Some will be 'in the clear' (Trinity Broadcasting, a religious-family service network with headquarters in Los Angeles is expected on PAS-2 by this October; for example), but most will employ some form of encoding. The subscription service programmers not affiliated with SKY (if SKY does go satellite-direct, it is likely two or more TVNZ packaged programme channels will also be offered 'in the same package') will look to installing dealers to 'represent' them as well; a subject discussed in some detail at the opening of this report. Dealers then will be offered the opportunity to not only earn income from the sale and servicing of home dish systems, but also as 'sales agents' for the software (programming) as well.

THE CUSTOMER TV INTERFACE

The satellite TV 'receiver' contains no CRT nor speaker; it delivers 'baseband video and audio' to a pair of output ports. Viewers with large screen, high-end television receivers will have the best displays by plugging directly into these receiver outputs and tape recording is best done from here as well.

The receiver itself is fairly transparent to terrestrial / satellite broadcasting format. It will process PAL or NTSC or SECAM without really caring what the format may have been originally.

But the interface to a DBS / DTH subscriber's receiver typically requires an RF 'modulated' signal. For this reason virtually all receivers provide a local-terrestrial-format (PAL in our case) modulator which outputs in the band V region around our channel 39. Now a PAL input signal at C or Ku comes out via the built-in modulator as PAL and the TV set plays the signal as it would any other PAL band V signal.

NTSC and SECAM signals require baseband 'transcoding;' a problem we are unlikely to experience on PAS-2 since the services there will be PAL to begin with. Transcoders have been available for more than a decade for those C band installations requiring same.

TECH BULLETIN 9405T

The next Tech Bulletin (October 17) focuses on commercial (motel et al) satellite systems.

SITE INSTALL STEPS

a) Know the site. In uneven terrain the site for the dish must be 'proofed' before an installation can be assured. For each site there is a known azimuth (direction to the satellite with true-north as 0 degrees) and a known elevation angle (number of degrees above the (flat) horizon the dish will point when the azimuth of the dish is pointed at the satellite).

b) With an accurate compass you can stand at the site and 'survey' the hills, trees, buildings in the 'satellite arc' region. With an inclinometer you can sight along the edge while holding the inclinometer at the proper (indicated) elevation angle to approximate the 'pathway' to the satellite and at the correct azimuth angle. If your 'sighting along the edge' of the inclinometer runs you into an obstruction (hill, big trees, building) try changing location. Ku band signals will not penetrate hills or buildings, and most trees will cost you valuable dBs of signal. From the proposed location of the dish to the intended satellite(s) you need a clear, unobstructed view.

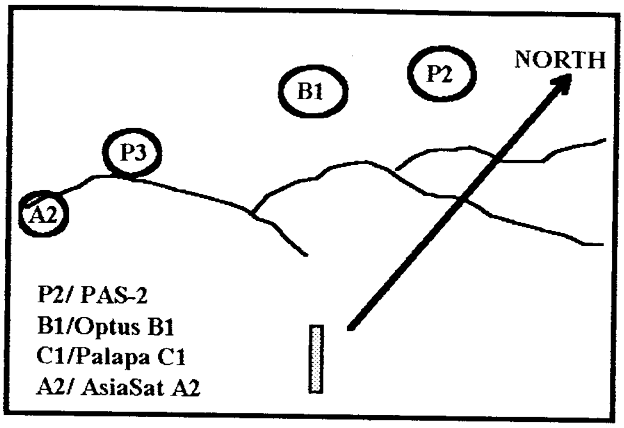
NOTE: Satellite 'Survey Tools' are commercially available that combine azimuth and elevation adjustments to allow you to quickly perform these checks.

c) A test antenna brought to a site, installed on a trailer, will have the disadvantage of being close to the ground. Most (Ku) satellite dishes will attach to the side of a building or at the roof line. Testing from a ground-based trailer may not always be practical, especially in areas with heavy vegetation.

d) The larger the antenna, the more complex locating the satellite will be. The size of the antenna determines its gain, but as the gain increases the antenna front 'pattern' narrows or sharpens significantly. Representative beam-widths for three Ku antenna sizes suggest the increasing aiming difficulty with larger dishes.

1.83m/Ku	1.2m/Ku	0.9m/Ku
1.0 degrees	1.65 degrees	2.1 degrees

REPRESENTATIVE Ku DISH BEAMWIDTHS



e) Questionable sites can be studied on paper by standing at the intended dish location, and using a compass plus inclinometer ('Siting Tool') plot the clearance of satellite elevations to various present/future satellites. In example above C1 and A2 are 1995 era (new) C-band satellites (CTD: 9312, p.2).

f) By knowing two co-ordinates (elevation and azimuth) you can boresight the satellite using appropriate antenna-set-up tools. Elevation is usually easiest to verify (using an inclinometer) while accurate azimuth (corrected for true north) can be more difficult.

This suggests use of a 'search pattern' where the dish is adjusted first for elevation and you then do +/- 5 /10 degree 'sweeps' of the azimuth direction search for the satellite. With a 1.2m dish if you come within 2 degrees of the actual satellite, you will see an indication of it and can then 'zero in'. The receiver must be pre-set to the known active satellite transponder, and the polarity of the feed set before the search begins. See diagram.