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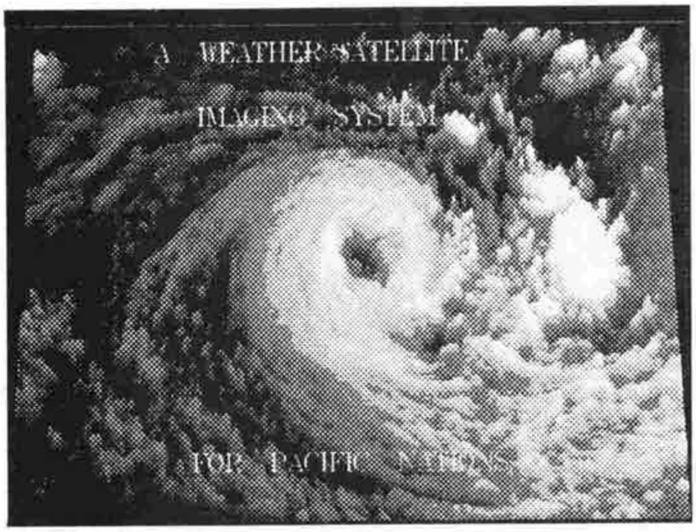

A Weather Satellite Receiving System for Pacific Island Nations

by

Colin Schulz

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A Weather Satellite Receiving System for Pacific Island Nations

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Colin Schulz

Consultant

Western Samoa

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Foreword

After the SPREP Climate Change Task Team successfully completed studies on the impacts of climate change and sea level rise in preparatory missions to Cook Islands, Federated States of Micronesia, Guam, Kiribati, Palau, Tokelau, Tonga, Tuvalu and Western Samoa; further in-depth studies were needed as clearly stated in all the recommendations. The United Nations Environment Programme (UNEP) provided financial assistance for these studies. The World Meteorological Organisation (WMO) and UNEP then provided further funds to implement these in-depth studies in 1994. SPREP is grateful to these two UN agencies for their assistance.

In carefully assessing these countries' recommendations in the preparatory mission, all urgently requested assistance for up-grading their meteorological capabilities in understanding, assessing and forecasting the cyclones. These events are becoming more frequent in the region, and cause enormous economic, environmental, cultural and social hardships to these countries.

This report reviews and up-dates information on technology and systems for receiving important forecasting data from weather satellites. These systems could be installed in these countries to assist them with their daily forecasting for weather, in particular cyclones.

Once countries obtain this equipment, SPREP can plan for installation and training activities in using these systems to their greatest benefit.

It is anticipated that once countries receive their systems, a communication net-work would be established to further assist countries, particularly in the tropical cyclone belts of the region.

Vili A. Fuavao

Director

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Executive Summary.

1. Introduction

All South Pacific countries have a need to monitor the weather conditions within the region especially during the cyclone season. An important tool to assist in monitoring and forecasting weather conditions is the weather satellite image.

Many of the smaller nations do not have facilities for reception of these images which are regularly available.

With recent advances in computer technology and image processing, the reception and display of these images is within the means of even the smallest country. Reasonably priced systems which provide automatic reception of satellite images can be purchased and installed for under $US 10,000.

This paper reviews some systems which are available and recommends a system which will meet the needs of the smaller Pacific nations at a realistic price.

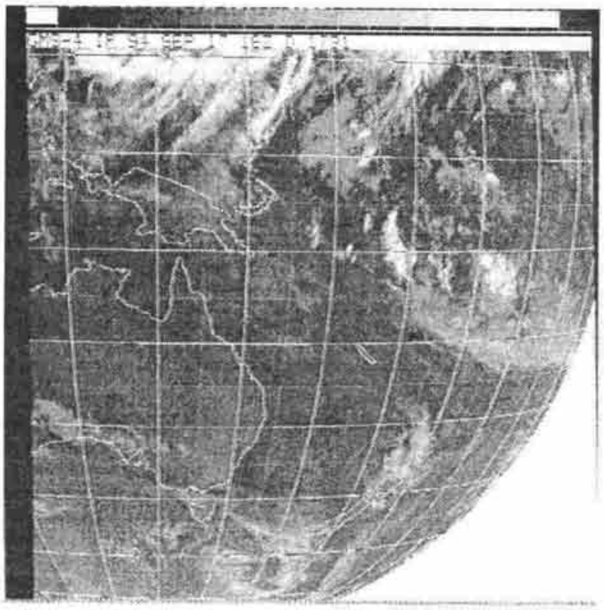

Fig. 1: Typical infra-red image from GMS4.

Adequate training in image interpretation and use of all other data available is essential to produce a forecast which is as accurate as possible.

2. Benefits to be gained from local receiving system

- Real time or near real time information.
- Independant source of data in the event of communications problems with distant forecast centres.
- Visual data which shows better the location and magnitude of a severe storm.
- Local staff can build up better local expertise in forecasting with access to real time visual images. The availablity of visual images gives them more incentive to apply their skills than when relying on interpretations from a distant centre.

It should be pointed out however that this equipment is only another tool to use in producing forecasts and does not in itself provide a complete answer. Having said this, it could be a valuable tool to assist the smaller meteoroligical stations within the Pacific region.

3. Recommendations

Since simple receiving equipment is now available at reasonable cost, it is recommended that:

1. *Steps be taken to acquire suitable equipment as soon as possible in those countries which do not have a system as yet or where their system is obsolete.*
2. *SPREP co-ordinate the purchase and commissioning of the selected system in some countries to enable field trials in a number of different situations.*
3. *That the Quorum Communications system be considered for the trials as it most closely fits the requirements of the smaller stations in the region at a reasonable cost.*
4. *The trial systems be installed as soon as possible to allow for adequate training and operator familiarisation before the 1994-95 cyclone season commences.*

5. *All equipment be assembled and thoroughly tested in Apia before shipping to it's final destination.*
6. *On receipt of the equipment in Apia the first system be installed at SPREP HQ with the participation of personnel from the other countries involved in the initial trials.*
7. *Following satisfactory installation and commissioning of the SPREP system this system should be used to train the staff from other countries who then would take their systems back to their own countries and complete the installations there with assistance from SREP if necessary.*
8. *SPREP act as a co-ordinator and resource centre for ongoing training and assist each country develop expertise in operating the system.*
9. *After a suitable period of evaluation recommendations be made regarding purchase of further systems for other countries.*
10. *Further training be arranged to develop skills in image interpretation.*

4. Cost Estimate

For a complete system fully operational on all available satellites the estimated equipment cost is approximately $US 7,000.

This includes the computer and all the equipment necessary to fully equip the station. Additional funds will be required for training and installation.

1. Background

There are a number of meteorological satellites which transmit images within the Pacific region and which use formats suitable for reception by simple receiving equipment.

The use of these images could be of assistance to the national weather services in day to day forcasting and also when there are major storms in the region.

Modern systems allow for reasonably accurate gridding of images which can assist in locating major storm centres.

The video displays available with modern computers allow high quality display of meteorological satellite images which can be further enhanced to provide useful information to suitably trained staff.

SPREP is interested in assisting the Pacific nations in obtaining suitable equipment which may be used in the region and this paper sets out the various options available, looks at various systems and recommends a system which will fit the needs of the smaller meteorological offices in the Pacific.

2. Satellites available in the Pacific Region

The satellites available in this region can be divided into two broad categories:

1. **Geostationary**; and,
2. **Polar Orbiting**.

The *Geostationary series* are located about 36,000 KM above the equator at various longitudes and appear stationary to an observer on earth. The other group are the *Polar Orbiting* satellites which orbit the earth at right angles to the equator and pass over the polar regions. Figure 2. illustrates the two types of satellites.

These satellites transmit two different image resolutions, *High Resolution* and *Medium Resolution*. The high resolution images are available to larger receiving stations who are equipped with suitable equipment. As this equipment is relatively expensive and complex the Medium Resolution images are most commonly used in the smaller stations.

The medium resolution images then are the subject of this paper. The images from the Geostationary series are commonly referred to as *Wefax* format while the Polar orbiters use the *APT* format.

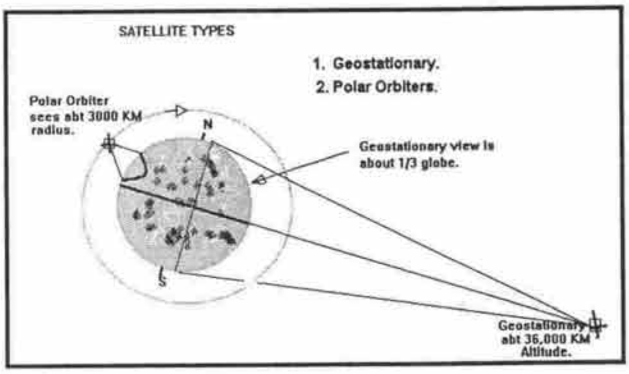

Fig. 2: Diagram showing two types of satellites.

3. The Geostationary Satellites

There are currently three geostationary satellites which transmit Wefax images likely to be useful in the South Pacific region. These are *GMS 4, GOES WEST and GOES EAST.* These satellites all transmit Wefax images on a frequency of 1691 MHz and because of the great distance (36,000 KM) from the earth's surface the ground receiving stations need good antennas and receivers to obtain satisfactory images.

The Wefax image from these satellites is a re-processed image which usually has Latitude and Longitude gridding, country outlines and other data added before being relayed to users. Each satellite covers a specific area and no single one provides total coverage of the Pacific region.

Because these images are always taken from the same location at regular intervals a series of these may be recorded and then later replayed rapidly to give an idea of cloud movement. This is known as *Animation* and can be very useful in displaying the general direction of circulation patterns and storm movements

The main characteristics for each satellite are given below.

3.1 GMS 4

This satellite is operated by the Japanese Met Service and is located at about 140 deg. East (just north of PNG.) It provides coverage from about 80 deg. East to about 160 deg. West and to within about 15 degrees of the poles. This means that it provides most useful coverage in the Western Pacific region. GMS 4 currently transmits Infra Red images of the globe at three hourly intervals with an estimated resolution of about 20 - 30 KM.

With this resolution major weather systems are readily seen and an indication is given of different cloud heights. This format is useful to gather a general appreciation of the main weather systems and their movement and is suitable for animation.

The global picture is divided into four segments, NW, NE, SW and SE designated A,B,C and D. The SE (D) segment covers the South West Pacific area. The images have latitude and longitude gridding and major country outlines superimposed on the image.

3.2 GOES EAST

This satellite is operated by the US and is located at about 110 deg. West longitude. Its field of view is from about 160 deg. West to about 60 deg West and so covers the Eastern Pacific and Americas. This satellite is of limited use in the Western Pacific except perhaps in Cook and Line Islands.

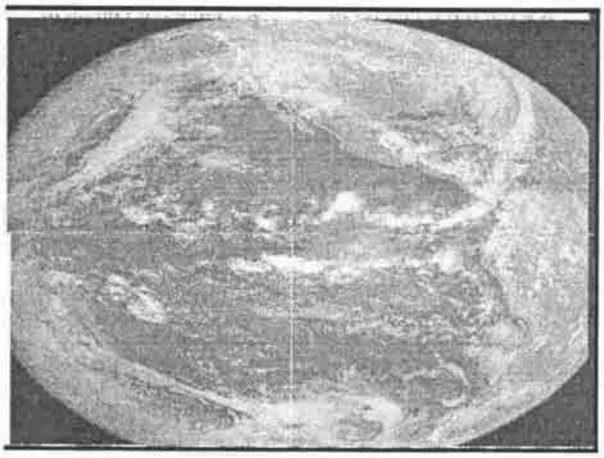

Fig. 3: Composite image constructed from four GOES EAST sectors.

3.3 GOES WEST

Goes West is an elderly satellite which is blind but whos radio relay apparatus is still in good condition. For this reason it is used as a relay satellite and as such re-transmits a range of images from other satellites as well as other meteorological information including surface and upper air charts etc.

The information relayed by this satellite is of value to the meteorological services in the Pacific as it includes images from GMS 4 and Goes East.

However Goes West is a little difficult to receive as it is in a rather unstable orbit and drifts about 8 degrees each side of the equator, This means that the receiving antenna must be moved slightly at regular intervals to keep track of it. However this is not too difficult a task and is worth the effort to obtain the data available.

It is expected that this satellite will be replaced in early 1995 with a more stable unit and when this occurrs it will not be necessary to constantly track it thus making it much more easy to use.

GMS 4 is then of most use in the Western Pacific and GOES West has something for everyone.

Most stations will probably want to use Goes West as their primary Geostationary satellite with GMS available as a backup in case of problems with GOES West.

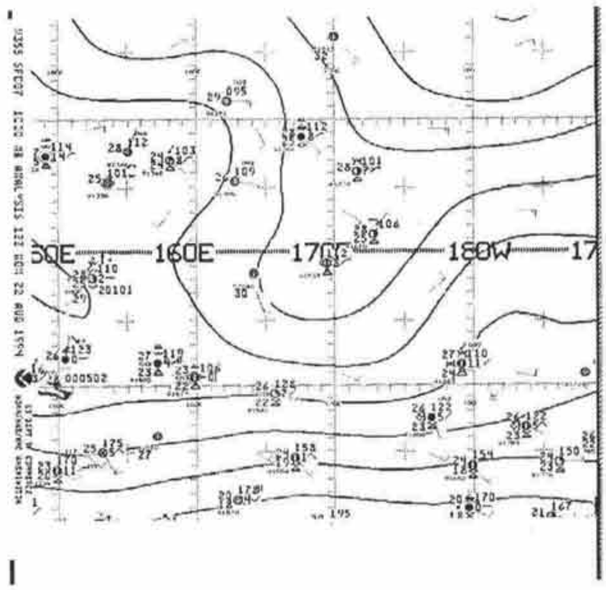

Fig. 4: Typical surface chart relayed by GOES WEST.

4. The Polar Orbiting Satellites.

These are a group of satellites in low polar orbits (about 800 Km) and which provide very good local images at various times during the day and night. They are operated by the USA and also CIS with possible additions from China at a later date.

Because of their continual movement and relatively low altitude they are only available for limited times twice each day. The normal coverage is about 1500 KM each side of their current track.

It is essential to have accurate tracking data to be able to predict when these satellites will be within range of the receiving station and to provide gridding. It is also desirable that the receiving equipment will automatically acquire the satellite and store the image for later analysis.

As these satellites orbits are continually changing some form of gridding is essential and most systems allow grids to be overlaid onto the image to obtain accurate geographical locations. Most gridding systems rely on accurate orbital data and time for their operation.

Accurate time is essential for accurate gridding and the best method to ensure correct time is to use the dial-up service of the National Institute of Standards and Technology in Boulder, Colorado. This service is very accurate and takes about 8 - 10 seconds to perform.

Current orbital data is available from a number of sources usually by dialling into a Bulletin Board service. The data available can be automatically transferred in a format which the tracking programme can use without the need to manually key in the information.

For normal use updates of orbital information at 2 weekly intervals is sufficient but for best accuracy especially for cyclone tracking it may be advisable to update weekly during the cyclone season. The cost of obtaining the data would be the cost of a 3 minute ISD call to USA. It may be possible for one of the Pacific stations (perhaps SPREP) to download the data from USA weekly and then the other regional countries obtain the data from SPREP as required. This could reduce operating costs.

These satellites transmit APT data in the 137 - 138 MHz VHF band and because of the frequencies used and the low altitude fairly simple antennas and receivers may be used.

The number of Polar Orbiters available at any time varies due to operational requirements but at the present time (Aug 1994) six are available.

The satellites operated by NOAA of the USA are designated *NOAA 9 - 12* and those of the CIS are the *Meteor* series.

The ground resolution of the NOAA series is about 4 KM and the Meteor series about 2 KM.

4.1 NOAA 9

This satellite is one of the NOAA series operated by the US and is the oldest in operation. It is currently received in mid morning (about 9 am) and again in the evening around 9 pm local times unless its orbit conflicts with NOAA 11 when it will be switched off. This occurrs infrequently.

NOAA 9 transmits both visual and IR images during the day and IR only at night. The current picture quality is very good with adequate light for the morning visual images to show the Pacific Islands clearly. NOAA 9 transmits on 137.620 MHz.

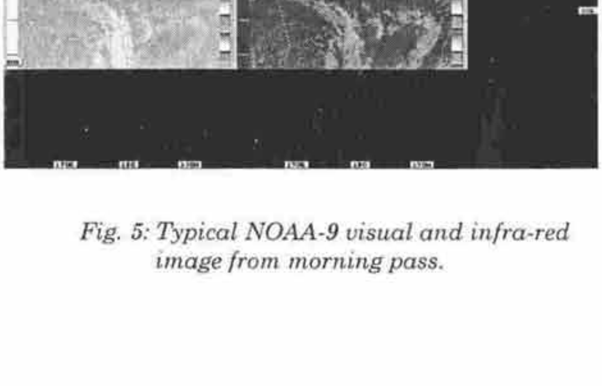

Fig. 5: Typical NOAA-9 visual and infra-red image from morning pass.

4.2 NOAA 10

NOAA 10 is also an older satellite still operational and has drifted into an early morning pass available around 7 am and again about 7 pm both local times. Both morning and evening passes now transmit IR images because of the very low light available in the early mornings. NOAA 10 is switched off fairly frequently while it's orbits conflict with NOAA 12 which also transmits on the frequency of 137.500 MHz.

4.3 NOAA 11

This satellite provides the primary afternoon service and is currently available about 4 pm and also 4 am local times. The visual image is a little dull because of the lower light level in the late afternoons but it still provides a useful image. Visual and IR images are transmitted diring the day and IR only at night. NOAA 11 uses the same frequency as NOAA 9, 137.620 MHz.

Since this report was originally compiled in August 1994, NOAA 11 has developed an imaging fault and is not avaialable at present. It is not known at this time (November 1994) if this problem will be rectified or not.

4.4 NOAA 12

NOAA 12 is the primary morning satellite and is available around 8am and again at 8pm local time.

It transmits visual and IR images during the day and IR images at night. Image quality is good although the visual image is a little dull during the middle of the year when there is less sunlight in the early morning. It transmits on 137.500 MHz.

4.5 NOAA 13

This satellite (as its name NOAA 13 implies !!) met with a disaster and ceased operation shortly after launch. It is no longer functioning.

4.6 NOAA 14

Noaa 14 is expected to be launched some time in 1995 and will replace one of the older satellites.

4.7 Meteor Series

These are a series of meteorological satellites operated by the CIS. They have a slightly different format from the NOAA series but most systems cater for them. There are usually one or two Meteors operational at any one time but the times and availability change frequently. Because of this they cannot be relied on and should be regarded as an additional source of images which may be available Most current packages cannot provide gridding of Meteor images which also reduces their value somewhat. It is to be expected that further improvements in the software will add gridding at a later date.

Their resolution is generally better than the NOAA satellites but the imaging sensors are not particularly sensitive to the darker greens of the Pacific Islands so the land may not show up clearly in most Meteor images. The cloud detail however is usually excellent.

4.8 NAFAX Images

While not satellite based these images are currently received by a number of stations around the Pacific by HF radio from Australia, New Zealand, Hawaii and perhaps Guam. Most products are charts but some stations transmit satellite images. The quality of the images is usually poor and subject to the usual propagation problems associated with HF radio. With a suitable HF receiver some programmes reviewed can display and print NAFAX images. This could be a useful backup facility for those stations who rely on this source of data.

5. A Basic Receiving System.

The basic equipment required to set up a simple station to receive Polar and Geostationary satellites is illustrated in Fig 6.

The main components are:-

1. Geostationary Dish Antenna.
2. Polar Orbiter (APT) Antenna.
3. Down Converter for Geostationary Satellites.
4. Main Receiver.
5. Image Processor and Processing software.
6. Computer and Display.
7. Printer.
8. Modem.

This section draws attention to certain features which are desirable in any good system.

5.1 Geostationary Antenna

This is usually a parabolic dish antenna designed to collect the radio signal and make it available to the receiver. An antenna of about 2 metre diameter is the recommended size to ensure adequate signal level for good quality images.

A mesh covered antenna is preferred to reduce the wind loading in high wind conditions and should be fitted with a suitable mounting to attach to a vertical pipe concreted into the ground.

The antenna also needs a feed assenbly to collect the radio energy. This feed assembly may also contain the down converter.

The main requirements for the antenna are:-

- Robust construction.
- Minimum wind resistance.
- Corrosion resistant.
- Simple to mount and adjust.
- Integral feed assembly and down converter in waterproof housing.

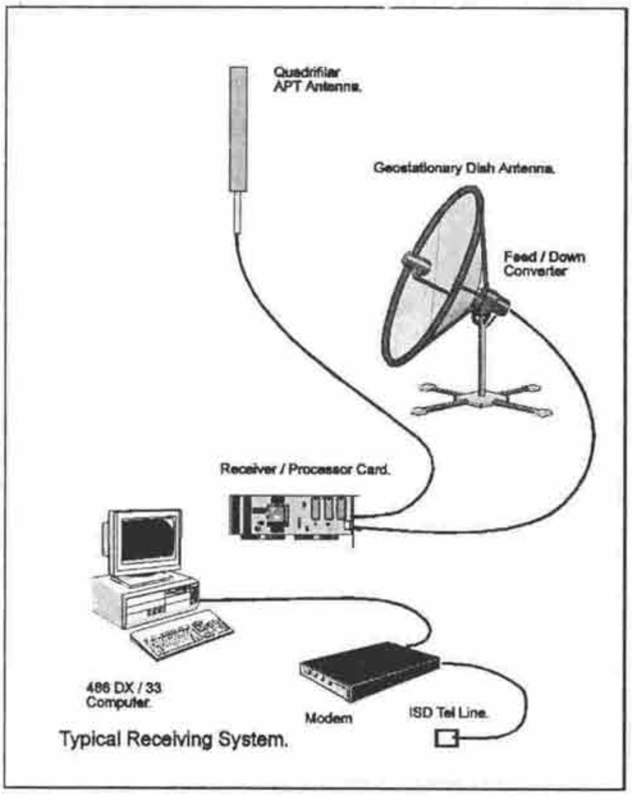

Fig. 6: Main components of a receiving station.

5.2 Polar Orbiter Antenna

Because the polar Orbiter satellites are continually moving and are at a reasonably low altitude a simple omni-directional antenna is sufficient for their reception. There are several types of antenna which will provide reasonably omni-directional coverage but the Quadrifilar Helix is recommended because of it's better performance and good weatherproof construction. A pre-amplifier mounted at the antenna is recommended to overcome cable losses.

A suitable antenna should meet the following requirements:-

- Robust corrosion resistant construction;
- Omni-directional radiation pattern;
- Circular polarisation; and,
- Built in low noise amplifier.

This antenna would usually be mounted in a clear location just above roof height for best results.

5.3 Down Converter

As the geostationary satellites transmit in the microwave band the signals are rapidly attenuated by normal interconnecting cables and to reduce losses it is usual to convert the signals to a lower frequency at the antenna and then pass them to a Polar Orbiter (APT) receiver for further processing. The Down Converter carries out this function.

A good down converter will contribute very little noise to the received signal and amplify it enough to ensure that there is no degradation by the interconnecting cable to the main receiver. The power required for operation of the down converter can be fed to it over the signal cable from the main receiver.

The most important features of the down converter are:-

- Weatherproof construction.
- Low noise figure. (less than 1 dB.)
- Adequate gain. (at least 20 - 30 dB gain)
- Preferably integrated with the antenna feed assembly.

5.4 Main APT Receiver

It is usual to operate the main receiver at the frequency of the Polar Orbiters (about 137 MHz) so it may be used for direct reception of these satellites.

The main receiver must be capable of receiving on any of the frequencies commonly in use now or in the future and most modern units are programable over the range 136 - 138 MHz.

The receiver must convert the signal into a suitable format for use by the image processor. If the system is to be used to directly receive GMS then the receiver must be a dual bandwidth type to be able to use the wide band transmissions from GMS.

The receiver may be a stand alone unit or it can be integrated with the image processor and be a plug-in card mounted in the PC.

The receiver should have the following features:-

- Cover full frequency range 136 - 138 MHz;
- Have adequate performance to ensure high quality images;
- Provide indication of received signal level;
- Provide power to down converter and preamplifiers;
- Have inputs for both geostationary and polar signals; and,
- Preferably be integrated with the processor for simplicity of installation and control.

5.5 Image Processor

The image processor converts the analogue data from the receiver into a digital format suitable for use in the computer. It samples the incoming signal, converts it into a digital stream, generates clock pulses for timing and performs other related functions.

It usually consists of a plug-in card which fits inside the computer. The image processing software (or programme) controls this card during reception of an image.

It is important that the sampling rate of the image processor is sufficiently high to ensure good quality images. Some cards are better than others in this regard.

The image processor should be:-

- Plugin card for PC using ISA bus;
- Provide adequate sampling rate. (at least 3200 samples/sec.);
- Have automatic level control to ensure consistent image quality; and,
- Be simple to install and setup.

5.5 Software

The programme used to control the processor (and sometimes the receiver) is most important as it provides the interface between the operator and the receiving system.

Its ease of use, the facilities available and so on are mostly controlled by the quality of the software. Different manufacturers incorporate different features which help make the system user friendly and so a great deal of attention must be paid to the quality of the programme.

Desirable features of the sotware are:

- Ease of use;
- Provide integrated tracking of Polar orbiters;
- Be able to process all desired satellite types;
- Suitable for unattended operation with automatic acquisition and storage of images for later analysis;
- Allow accurate gridding of Polar images;
- Allow image enhancement with standard NOAA curves as well as custom formats;
- Permit use of false color for image enhancement;
- Storage of images in recognised standard formats (GIF, PCX, TIFF, JPEG, etc.);
- Built in Scheduler for presetting image capture;
- Animation of geostationary images;
- Allow printing of images; and,
- Temperature and distance readout on polar images.

5.6 Computer and Display

The received image will be processed by the programme running on a computer and then displayed on its VDU. The computer selected should be of adequate performance to carry out these tasks properly.

It is recommended that the computer be totally dedicated to this job and not be used for any other task.

The main requirements for a suitable computer are reliable operation, good video quality and a fast maths processor. As many of the functions of the programme are very maths intensive it is imperative that the computer has a built in maths co-processor.

Adequate memory is also important as the image is stored in memory for processing and a minimum of 5 megabytes is needed. Because typical images files occupy about 3 megabytes adequate hard disk capacity for archiving interesting images is needed. A hard drive of at least 270 Mb capacity is recommended

To provide reasonably quick screen updates local bus video is also recommended. The video card and VDU must be capable of SVGA with a display of at least 1024 x 762 pixel resolution. The video card must be VESA compatable.

Most programmes make extensive use of a mouse so this is a mandatory requirement. The operating system should be MS-DOS 6.2. Windows is not required and should not be installed.

A suitable computer will have the following minimum specifications:-

- 486 DX /33 Processor running DOS 6.2;
- Minimum of 5 Megabytes RAM;
- Minimum 270 Megabyte Hard Drive;
- SVGA local bus graphics card with 1 Megabyte RAM. & VESA compatability;
- 3.5 inch Floppy Drive;
- MS compatible mouse; and,
- Proven reliability and backup service.

Perhaps the most important item is reliability and adequate backup service. Purchase of a proven reliable brand name is essential.

As the machine will most likely be in use 24 hours of the day a suitable power line filter and UPS are also essential. Since a modem will also be used a combined power line and modem line filter is recommended.

Most computer clocks are rather inaccurate and a software correction programme is recommended to ensure accurate timekeeping. A good time setting programme is also useful.

5.7 Modem

A modem is needed to update the tracking data and is also useful to set the computer clock accurately.

Accurate and up to date tracking data and time are essential for accurate gridding of APT images.

The modem should have:-

- 9.6 KBS capability;
- Be supplied with a simple communications programme;
- Be supplied with interconnection cables; and,
- Be Hayes compatible.

5.8 Printer

To enable hard copies to be made of received images a suitable printer is also recommended.

The printer recommended is the Hewlett Packard Deskjet 4-L. which is reasonably priced and provides good quality prints.

The running costs of this type of printer are somewhat higher than for a normal dot matrix printer but the quality of print from a dot matrix unit is totally inadequate. Print costs are estimated at about USD 0.05 cents per copy.

A printer is not essential to the operation of the system and may be omitted if a reduction in overall cost is necessary.

6. A Practical System for the Region.

Any system chosen must then provide the following features

- Be capable of receiving all satellites considered useful within the region;
- Be simple to install, operate and maintain;
- As much as possible automate the capture process to allow for unattended operation;
- Provide images which are as near as possible to the original transmitted quality;
- Provide Gridding on the Polar satellite images;
- Allow image enhancement and the use of false color;
- Allow reasonably accurate sea surface and cloud-top temperature measurements;
- Provide animated images from the Geostationary satellites;
- Be supplied by a manufacturer with a proven record preferably as a complete ready to install package; and,
- Allow reception of NAFAX images if suitable HF receiver available.

6.1 Review of Systems currently available and tested in the region

A number of systems have been tested in the region and some general observations about their performance would be in order. The remarks apply to the particular model as it was tested and to any revisions which may have been noted. However as the state of the art advances each day so to speak it is difficult to keep entirely up to date with the latest revisions to a particular system.

There are a number of manufacturers in the USA and UK in particular who have a reputation for quality products. A comparison table is given at the end of this section showing the main features of each system reviewed. This is by no means a complete list of all systems available.

6.1.1 Timestep (UK)

The Timestep Prosat II system has been available for some time and is in use in a number of locations round the Pacific. It is a relatively simple system to use but suffers from one or two deficiencies which detract from it's usefulness as an unattended system.

The sampling rate is rather low which results in medium quality images and it does not have an integrated tracking system. It does have a scheduler but the data must be manually loaded into it after compiling from a tracking programme. The level setting for Polar Orbiters is manual and this leads to some inconsistent levels of image brightness with different satellites.

A separate VHF receiver is required which can be supplied by Timestep but this does not have a Signal strength indicator which is necessary for quick Geostationary antenna alignment. It does not have a suitable bandwidth for GMS4.

Prosat does not allow reception of NAFAX transmissions.

On the positive side it has a very fast gridding system which also allows for correction of small errors due to time or tracking errors.

Most other desirable features are incorporated and this is the first programme currently available which attempts to grid Meteor images with any measure of success.

The approximate cost for a complete system excluding GMS capability and computer is about US$ 3,500 plus shipping.

6.1.2 OFS Weather Fax

This system is produced in the USA and is in use fairly extensively there. In practice is it a rather difficult programme to use and also the version tested suffers from some random noise in contrast expanded images. The same remarks apply to this unit as to the Timestep system with regard to automatic unattended operation where the data must be loaded manually at regular intervals into it's scheduler.

OFS will decode the HF Nafax transmissions and all other available satellites but synchronising to the picture image can be a little erratic at times.

A separate VHF receiver is also required with this package.

Total cost excluding computer would be about $US 3,500 - $US 4,000 with GMS capability included.

6.1.3 Brisbane (Australia) design

There are three small manufacturers in Brisbane who between them produce a part system. An early version was tested in Samoa and found to be very difficult to set up. It did not have integrated capture and tracking and a number of desirable features were missing. This system is not in commercial production and is also incomplete so will not be further considered.

6.1.4 Alden (USA)

Alden have been producing weather satellite receiving systems for many years and there are a number of Alden systems in use in the Pacific. Most of these are quite old and use electrolytic paper as the printing medium. They do not offer any modern features and will most likely be replaced. The latest Alden system uses computer technology but is not based on MS-DOS and is very expensive. It is considered too expensive for most small countries.

Typical prices for a complete system are in the vicinity of $US 50,000 - 60,000 which includes a computer and printer.

6.1.5 Quorum Communications (USA)

This company produce the Wefax Explorer and Wefax Professional integrated receiver and decoder card, antenna systems & cables together with appropriate software.

The programme has several excellent features to make it eminently suitable for unattended operation. The integrated prediction, tracking maps and scheduler make this programme simple to use and to automatically capture images and store them on the hard disk.

The main negative feature is the need to reload the image from hard disk into a viewing module for image gridding and enhancement. The initial image presented on the screen during capture is somewhat smaller than the other programmes reviewed due to the presentation of tracking and other data on the screen at the same time. However this is not considered a major problem.

The combined receiver and image decoder/ processor make for a neat installation which is simple to install and use.

The receiver is under the control of the tracking and prediction module and is set to the correct channel automatically at the correct time for capture of the next image.

The Wefax Pro card has a dual bandwidth receiver suitable for GMS4 and this mode is automatically selected under programme control as required.

The package price for a system including GMS capability but excluding the computer and printer is about $US 3,500 which compares favourably with the other packages.

6.2 Comparison of systems

A comparison of the system described is shown in Table 1.

Table 1: Comparison of available weather systems.

	Timestep	OFS	AUST.	ALDEN	QUORUM
GMS capable	No	Yes	Yes	Yes	Yes
Auto-track	No	No	No	No	Yes
Animation	Yes	Yes	Yes	Yes	Yes
Gridding	Yes	Yes	No	Yes	Yes
False Colour	Yes	Yes	No	Yes	Yes
Sample Rate	1600	2048	?	?	1800
Integrated Receiver	No	No	No	No	Yes
Simple to use	Good	Fair	Poor	?	Good

7. A suitable system for the Pacific islands

7.1 Computer

There are many computer manufacturers who can provide a suitable unit but two have been selected for evaluation as being of proven reliability and reasonable price.

SPREP is currently using DELL computers from USA and supplied by South Seas Computers of Suva, Fiji. They have had good service from these machines.

Another manufacturer with an excellent reputation for quality equipment at reasonable cost is PC DIRECT of New Zealand. There are a considerable number of these machines in use in Western Samoa. .These machines are also a little less expensive than the DELL.

It will be essential to include a UPS as part of the package to provide protection against short term power outages. It is expected that most Met Offices will have some form of standby power to cater for the longer term power failures.

7.2 The Satellite Receiving System

The Quorum Communications system best meets the requirements previously stated. In addition it has a number of features not found in any of the other packages. These include a tracking map showing the actual image coverage area both during acquisition and also in the View mode. Automatic labeling of NOAA images including the channel number is a useful facility not found in the other programmes as is the integrated receiver and processor which places the receiver under full control of the tracking programme.

Quorum have an optional integrated feedhorn/down converter available which reduces losses and also eliminates a number of points where water may penetrate the system making for better overall reliability. It is recommended that this integrated feed / down converter be used.

The **recommended parts list** from Quorum Communications then is:-

1. WEFAX PROFESSIONAL Integrated receiver / capture board.
2. Integrated WEFAX Feed / downconverter
3. Unimesh 6 foot EL/AZ Mount Disk with 3 inch Pipe mounting.
4. Quadrifilar APT antenna (Marine grade.)
5. 100 ft APT antenna cable RG58 Double shielded.
6. 100 ft WEFAX interconnect cable RG58 Double shielded.
7. Down Converter Power Supply 230 volts AC to 12 VDC.
8. QFAX 3.xx software.
9. Rightime clock correction software
10. Timeset clock setting software.

7.3 Budget Considerations

For the purposes of estimating the cost of a system budgetry prices have been obtained from two suppliers of computers and from Quorum Communications. These prices are for budgetry purposes only and may be subject to change.

7.3.1 Option 1

Computer: (From South Seas Computing Fiji).	**Total**
Del OptiPlex 486DX/33 8Meg RAM 270 Mb HD, 3.5" FD 14"SVGA monitor, mouse and keyboard (including Freight.)	$US 2422
Printer: P Laserjet IV-L	$US 1000
Internal Modem	$US 200
UPS Power Supply	$US 257
Total Cost	**$US 3879**

7.3.2 Option 2.

Computer: (From PC DIRECT N.Z.)	Totals
PC Direct 486VL 486DX2/50 8MB RAM, 340MB HD 3.5" FD, mouse and keyboard, 14" SVGA Monitor.	$NZ 2848
Prnter: HP Laserjet IV-L	$NZ 1500
Internal Modem	$NZ 200
UPS Power Supply	$NZ 700
Estimated **Freight.**	$NZ 500
Total Cost	**$NZ 5748 (US$ 2310)**

7.4 Quorum Communications Equipment

Equipment	Totals
Wefax Professional Receiver / Processor Board	$US 1300
Unimesh Dish Antenna 6'	$US 425
Integrated feed / down converter	$US 1350
V20A Quadrifilar APT antenna	$US 600
Down Converter Power Supply	$US 20
Cable Wefax 100'	$US 70
Cable APT 100'	$US 75
Timeset Programme	$US 25
Rightime Programme	$US 25
Estimated Freight	$US 500
Total Cost (for individual items)	**$US 4390**
Special package price	***$US 3200***
Package incl.Freight	***$US 3700***

7.5 Total System Cost

Equipment	Total
Computer System (PC Direct)	$US 2310
Qfax System	$US 3700
Total System Cost	**$US 6010**

7.6 Training

An essential part of any project of this nature is training. While the equipment suggested is simple to use the interpretation of the images is more difficult and it is recommended that some source of training covering this aspect be identified.

Also there will be a small amount of preventative maintenance required and this must also be covered in the training for the operators.

As previously suggested, if the operators are involved in the initial installation exercise then this will assist in obtaining a good understanding of the system.

A minimum of experience in use of a computer is required and so it is not essential for the operators to have had training in this area. All operations will be initiated by simple batch files to reduce the need for operators to use DOS commands.

It is recommended then that there be two levels of training, one covering the operation and maintenance of the system and another covering image interpretation.

The basic operator training should not take any more than two or three days but the image interpretation training may be considerably longer.

It may be advisable to allow the operators to become familiar with the systems first before commencing the image interpretation course.

It is further recommended that SPREP personnel become familiar with the system and then be able to offer advice and assistance to the other operators if and when required. As previously mentioned SPREP should become the co-ordinating and information centre for this project and their staff should be encouraged to continue to develop their expertise in this area.

8. Operational Aspects of the system

8.1 Acquisition of Polar Orbiter Tracking Data

There are a number of sources that supply the accurate tracking data necessary to grid the APT images.

The simplest method is to download the data from a Bulletin Board via modem in a form readily usable by the Qfax programme.

A few of the possible sources of this data are:

- Celestial BBS in USA. operated by Dr T.S. Kelso of USAF.
- Remote Imaging Group BBS in UK.

Both these BBS do not require a subscription at present but they do suggest a donation to assist with the costs of operation.

The Remote Imaging Group has a good newsletter which covers many aspects of remote imaging using the meteorological satellites which is available on annual subscription and is recommended reading for anyone interested in the more technical aspects of the subject. It would be useful for SPREP to subscribe to this and one or two other journals which have details of satellite operations, launches etc.

Another Journal which provides operational data is the WEATHERSAT INK of USA. Both these also publish tracking data every three months. This is a little too long to wait for updates though for accurate tracking.

Until Tokelau Islands have a reliable telephone link it will be difficult for them to obtain up to date tracking data and perhaps the best way to assist would be for SPREP to supply the latest data on 3.5" disk each time a boat is going from Apia. This could be co-ordinated with the Tokelau Affairs Office in Apia.

As previously mentioned it may be better for SPREP to obtain the orbital data weekly and the other stations to obtain it from SPREP as required.

8.2 Archiving of Images

No provision has been made at this stage to provide long term storage of images. A typical uncompressed image from a Polar Orbiter will occupy about 2.5 - 3 Megabytes of disk space.

As the computers recommended have about 250 - 350 megabytes of disk space about 100 images can be held as an absolute maximum without some special measures being taken.

There are a number of options available for long term storage of data including optical WORM drives, Tape backup systems etc, but each has a number of disadvantages at this time,

Optical systems are still very expensive although the life of the storage medium should be very long.

With tape backup the tapes must be stored in an air conditioned environment which may not always be available. It is also difficult to access a particular image from tape.

It is recommended to wait until better methods become available before acquiring a long term storage device.

If it is desired to save a particular image long term (perhaps of a severe storm or other interesting item) then the best method at present is possibly to set up an archive sub directory on the hard drive and to use a file compression programme to reduce the size of the file. In this way a limited number of particularly interesting images can be retained without taking so much disk space.

QFAX has a number of compression systems built in and the image can be compressed using one of these formats after any coloring and enhancement is carried out.

Some of the available formats are GIFF, PCX and JPEG. Of these JPEG offers the best compression but is rather slow. This would not be a problem for occasional use. QFAX allows viewing of files which have been compressed but they may not be able to be re-processed.

8.3 Maintenance arrangements

The equipment chosen for this project was selected partly because of its good reliability. However any complex electronic equipment can fail due to a number of reasons, some being beyond the manufacturer's control. It is possible that a lightning strike in the immediate vicinity of the equipment could damage the down converter for instance.

The equipment is reasonably well protected from surges which could be caused by lightning but it is doubtful that any protection measures would be totally effective for a very close or direct strike.

The equipment recommended is covered by warranty for at least one year but this does not help quick restoration if a system is out of action due to component failure.

The turn around time from the manufacturer for repairs can be rather long considering shipping times, customs clearance and so on so it may be worthwhile holding a set of "critical spares" at a central location such as SPREP to cover such possiblities.

The minimum recommended spares would be:

- Integrated Feed Assembly/ Down converter (qty 1);
- WEFAX Professional Receiver / Processor Card (qty 1);
- Quadrifilar Antenna (qty 1);
- Computer complete (qty 1); and,
- Down Converter Power Supply (qty 1).

These items contain active devices which can be damaged by lightning. This would be the most likely cause of system failure.

It may not be desirable to implement this until a larger number of systems are in the field but it is offered as a suggestion for ensuring rapid restoration of a system that may have failed.

9. Summary

This paper has briefly surveyed the various meteorological satellite images available for reception in the Pacific area and given some details of the requirements for receiving these images.

It has also attempted to identify a system which will fulfil the requirements of the smaller meteorological stations (and could well serve as a backup system for the larger ones).

The ability to receive weather satellite images locally in the met offices of the smaller Pacific nations would enhance their forecasting abilities especially during the cyclone season. Many of the smaller countries do not have this capability at present.

The cost of providing a reasonable system is less than $US 10,000 per station.

Equipment to provide these facilities is currently available and is reasonably simple to operate while giving good quality images.

The system chosen will provide for reception of both Geostationary and Polar orbiter images.

It is PC-based and provides, as nearly as possible, automatic acquisition of the images.

It is suggested that SPREP co-ordinate a trial of suitable equipment in a number of locations so more experience can be gained in this area and that steps be taken to purchase this as soon as possible.

It is hoped that the information contained in this paper can be of assistance in providing a suitable system to the Pacific Meteorological Services and other organisations who may require them.