A SATELLITE NETWORK PROJECT DESIGN AND IMPLEMENTATION

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Bio

Peter Williams is the Technical Director of Marine-Air Systems Ltd, a Wellington-based electronics company. He graduated from Victoria University of Wellington in 1976 with a BSc Degree in Physics and Information Science.

Peter undertook a wide range of undergraduate work in electronics design and construction, ranging from audio, HF and VHF radio frequency and microwave technology to digital and computing electronics.

He was employed by Computer Consultants Ltd as Research and Development Manager from 1979 to 1983. Here he was responsible for the introduction to New Zealand, consisting of technical planning and support, of large computer systems produced by Harris Corporation and A4DS-Qantel Corporation as well as mini-computer systems, word processors and a Videotex system.) He also designed data communications products operating with a variety of protocols.

Peter joined Marine-Air Systems Ltd in 1984 where he established a development laboratory for hardware and software projects.

He has been project leader for the following design and development work:
Microwave satellite TV receivers
Specialised video decoders and demultiplexers
Ultra high gain amplifiers for load cells
Tone signalling equipment for military telephones
UHF radio control systems for military use Satellite earth stations for telecommunications
Digital microwave link for telecommunications

When I was first asked to present the Slade Memorial lecture I thought back on the wide range of unusual projects I have led at Marine-Air Systems Ltd and how interesting any or all of these would be to discuss. They not only cover a variety of significant technical challenges but also provide an excellent illustration of how a small New Zealand company can compete and grow in the International Electronics marketplace.

In fact, I have chosen one particular project to describe which typifies the sort of challenges and rewards which make up our business. The replacement PEACESAT Satellite Network is a project which we first became involved in less than three years ago and has now been successfully implemented for some months.
I have known about the PEACESAT project for a number of years from the days when it was implemented on the now defunct United States ATS-1 experimental satellite. The original network was run from the University of Hawaii and linked educational facilities around the Pacific using low cost VHF

equipment. However, it suffered from poor performance due to satellite limitations and variable quality of earth station equipment which in many cases was built by the schools and Universities themselves. A few years ago the ATS-1 satellite ran out of station keeping fuel and has drifted into an unstable orbit bringing an abrupt end to the old PEACESAT Network.

In 1989 we were contacted by the local PEACESAT user group and asked if our company was interested in bidding for the replacement satellite network. The US Congress had just approved a considerable grant of aid money to assist education around the Pacific by providing a new PEACESAT Network. We were attracted by the concept, as it was a logical extension of our experience with the lNMARSAT, INTELSAT and AUSSAT satellite systems. The thought of a considerable amount of money also caught our attention so we eagerly contacted the authority in Washington administering the grant, the National Telecommunications and Information Administration (NTLA), who are part of the US Department of Commerce. They sent us a copy of the Request for Information which laid out the technical parameters required of the Network, and asked interested companies to propose suitable Earth Stations and satellite. The words 'and satellite' caught us by surprise because at the time we did not have a large inventory of spare satellites at our disposal. However, not to be put off I called the contract administrator and explained that our expertise was in the area of Earth Station design and that we could offer a very competitive ground segment for the Network. lt turned out that they had not received many proposals which included satellites and those which did were well above their budget of only a few million dollars. The contract administrator had in fact been talking to NOAA, the US National Oceanographic and Atmospheric Administration, about surplus satellites. There were some meteorological satellites in orbit which were unusable for their original purpose because the cameras had failed, but they still contained a viable communications transponder. We provided a proposal to NTIA giving indicative costs of suitable Earth Stations but heard nothing from them until that they announced that they had reached agreement with NOAA to use one of these satellites. In due course we received a Request for Proposals From NTIA, this time detailing the specifications for the network and suggesting the use of the GEOS-3 met satellite. (See Figure 1)

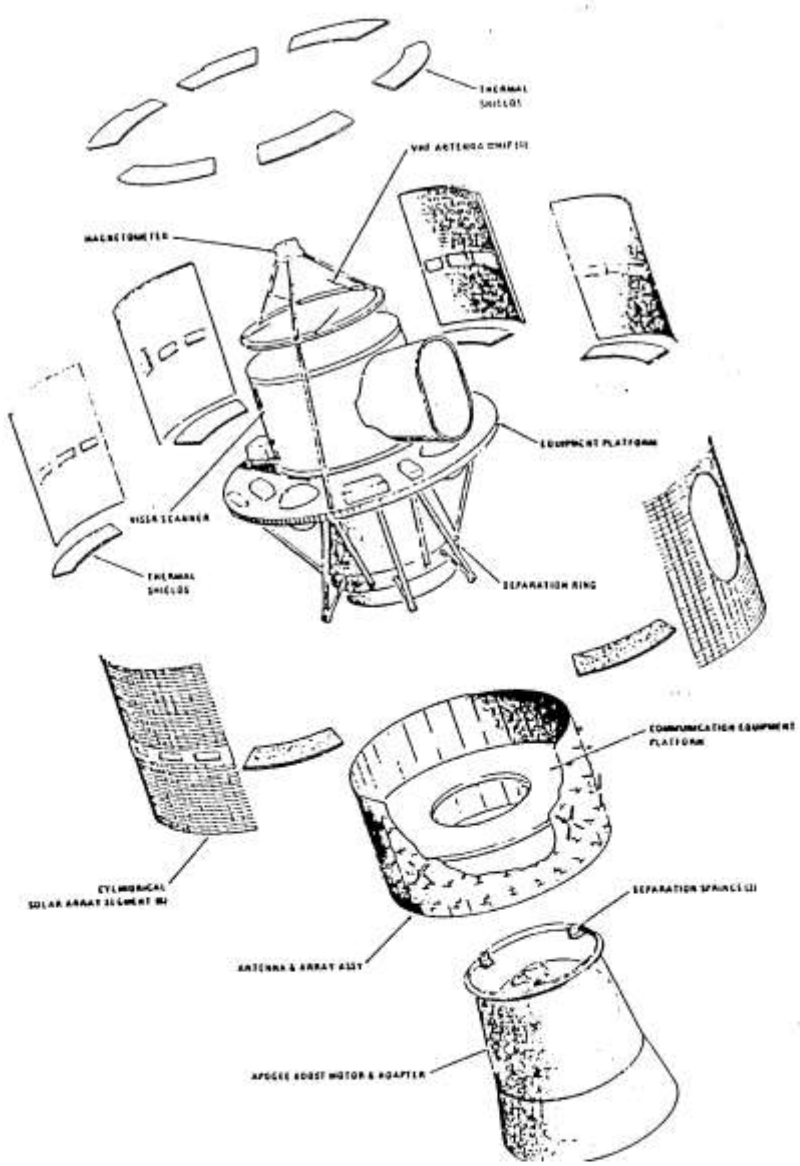

Figure 1: Exploded view of GOES-3 metrological satellite showing communications equipment platforms and antennas

The RRP came out in late 1989 and was advertised worldwide. As with the best planned Government tenders the response was due on December 25. Admittedly, with the time difference to the USA, we did in fact have Boxing Day to complete it before FAXing it through to Washington. Responding to this tender was a significant challenge in itself. Basically the technical part of the RFP merely stated that the System had to provide at least 3 voice and data channels of acceptable quality, and gave brief technical details of the satellite parameters. Because the satellite had been designed to relay single wideband imaging transmission, using an uplink Earth Station having a 30-metre dish, there was no information available on its use for multiple narrowband signals. We had to design the entire network from the ground up, including link budgets and intermodulation calculations before we could even settle on what dish size, modulation and signal bandwidths to use. To make matters more difficult the satellite, although in a geostationary orbit, has its orbital axis inclined with respect to the equator, necessitating a tracking system for the dish. (See Figure 2).

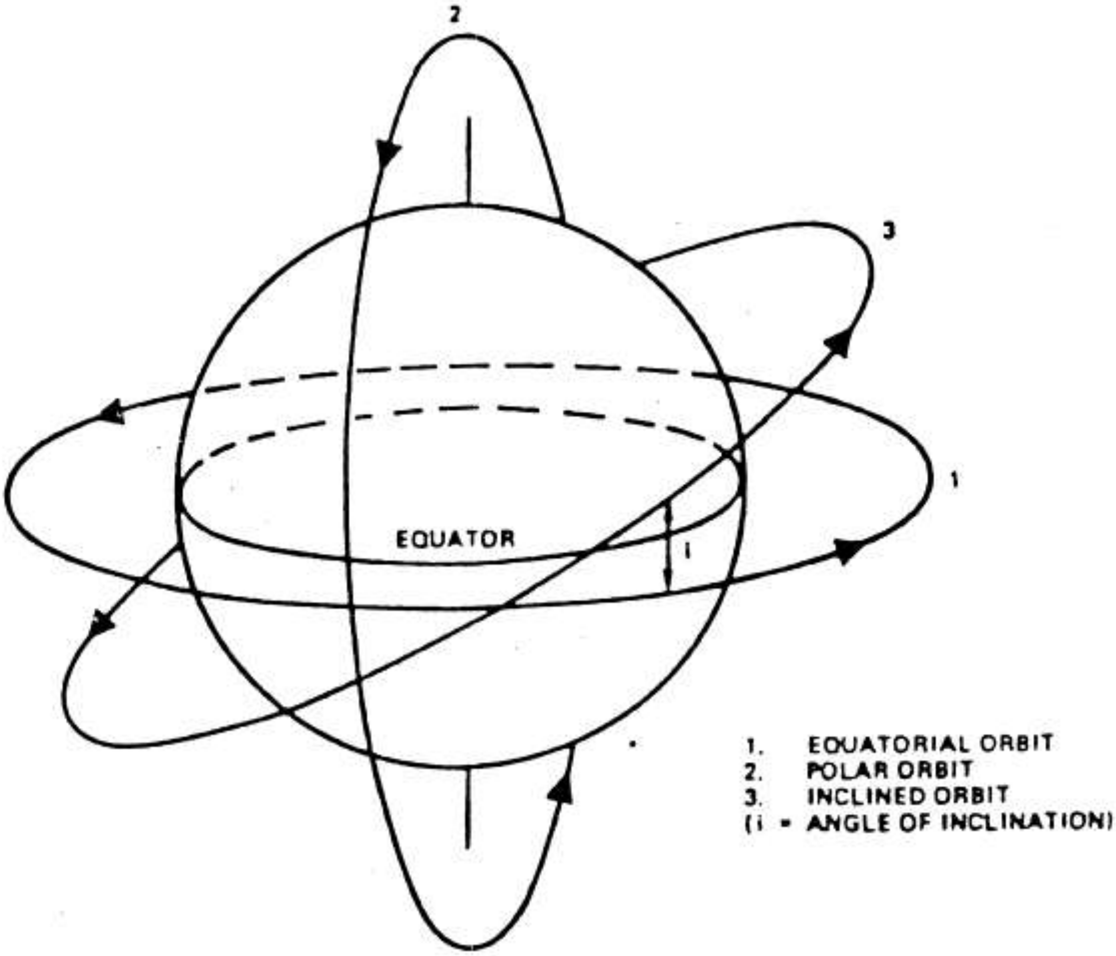

Figure 2: Types of satellite orbit GOES-3 with angle of inclination 8^0

On top of all this the terminals needed to be low cost and simple enough to he installed and maintained on the Island sites using non-technical staff having in many cases only secondary education. Because the satellite uses a specific meteorological frequency band at 2 GHz for uplink, we could not source standard microwave assemblies as is possible for traditional communications satellites. At least when offering terminals on satellites such as INTELSAT or AUSSAT, the Satellite owners have done the hard work of specifying the type of Earth Station required for different classes of service. Our biggest challenge was to be able to provide firm, fixed price for this Network design of 27 terminals which only existed on paper. Because of the shortage of time to respond, we could not carry out a detailed design or costing of many aspects of the contract.

As with most US contracts the less than two pages of technical data was accompanied by over 50 pages of legal jargon tying us into meeting exactly what we had offered, and imposing heavy financial penalties for not performing or withdrawing our bid at any stage.
It was with some apprehension that we awaited the decision on the contract. We were advised that we had made the short list with another company, Westinghouse Corporation of the USA, who had built the original satellite tracking and control station and could he said to have a slight advantage. After a few weeks of negotiation we were successful in being awarded the contract, not only on the basis of' price but also for offering the customer all the features they wanted.

(See Figure 3). We included a number of design innovations such as an interface to the Public Switched Telephone Network and the ability to separate the dish from the control electronics using a single, long, cable.

Figure 3: Neville Jordan (centre) MD of Marine-Air Systems Ltd signs the contract for 27 PEACESAT earth stations, witnessed by Mrs. Della Newman, US Ambassador, and the Hon. Ralph Maxwell, Associate Minister of External relations & Trade.

The next phase of the contract was the detailed technical design. It was then we discovered some of the problems we had let ourselves in for. For example, we had priced the 2 GHz High Power Amplifier, or HPA, for the transmitter at about $5,000 based on the 1.6 GHz versions available for INMARSAT. When we went out for quotes to all known suppliers of similar devices it turned out that nobody made one for the 2 GHz hand. The best quotes we received were about $15,000 each and, by the way, there was a $2000,000 up front development fee.
We therefore; designed our own amplifier using microstriplines on special Alunmina-Tefflon substrate. It had to operate reliably in continuous duty in hot tropical climates with no forced air cooling, and be protected against infinite load mismatches from a faulty antenna. A far as we know, this is the first design to use such technology in New Zealand. (See Figure 4). As well as the High Power Amplifier we needed to design filters, duplexers, converters and low noise amplifiers at the component level.

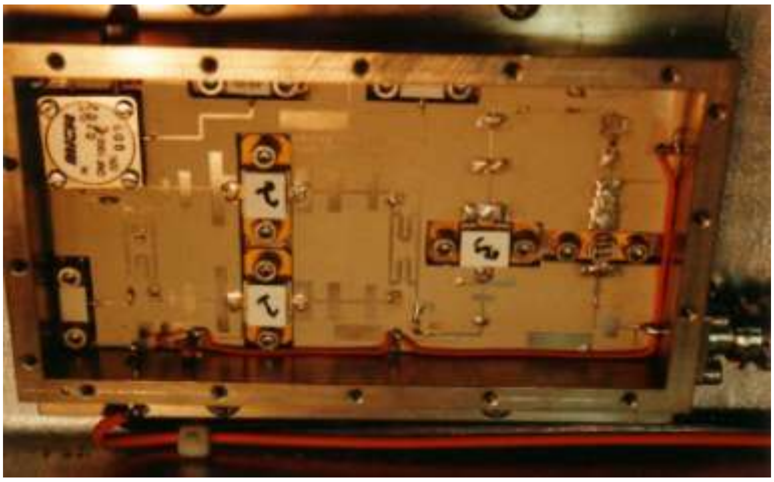

Figure 4: Prototype s-band High Power Amplifier using striplines on alumina-teflon substrate.

Another challenge was the antenna design which called for a 3 metre diameter parabolic dish. Our original plan was to use the low cost Satellite Television dishes available from Taiwan. After spending some time becoming familiar with their mechanical construction, and toe calculation of wind loadings, it became obvious that they would not withstand the 160 km/h winds optimistically stated in their specification. Also the painted steel construction would not survive long in a hot, humid salt laden tropical atmosphere. We decided to work together with a New Zealand company for whom we had previously manufactured Satellite television receivers to produce a suitable dish. We took their existing design and modified it by using only aluminium and galvanised steel construction, is well as designing a new mounting pedestal to provide tracking of the inclined satellite orbit using a motorised drive in only one axis. (See Figure 5). We also needed to design a simple method of attaching the dish to the ground which could be constructed with simple materials available on the Islands. (See Figures 6,7,8).

Figure: 5 Terminal at South Pacific Commission in Fiji, showing single axis motorised drive.

Figure 6: Terminals installed at the Forum Fisheries agency in Honiara, Solomon Is, showing concrete mounting pedestal.

Figure 7: Terminal located at Kosrae, Federated States of Micronesia.

Figure 8: Indoor electronics assembly at Saipan, Northern Marianas Is.

The antenna feed assembly presented some problems in designing a waterproof shroud for the radiating element having low loss at microwave frequencies. We spent some time testing various materials by measuring their temperature rise in a microwave oven.

The success of the antennas is evident from the fact that they have withstood cyclones in locations such as Guam, Vanuatu, Marshall Islands and both Western and American Samoa. In fact, the PEACESAT terminal provided some of the initial communications to Western Samoa after the recent cyclone Val, even before the INTELSAT Ear1h Station or other transportable stations were up and running.

The microwave portion of the Terminal Electronics is located outdoors in a single waterproof box at the antenna cut down on cable losses. (See Figure 9).

Figure 9: View of terminals on the roof of University of Hawaii building, showing white cast box containing microwave electronics

All the low frequency and audio processing electronics is contained in a modular rack system so that individual modules cam he readily replaced by the users. During the design phase a team from NTIA the University of Hawaii and the University of Florida visited MAS to carry out a Preliminary Design Review where we presented details of the proposed design and operation of the network. Most of the subsequent discussion centred on items such as the labelling of the front panel controls, either an indication that we had the more important items under control, or the customer was leaving us to discover the problems.

A second Critical Design Review took place at the University of Hawaii, at which we presented the final design. Also a number of additional options and the proposed system for tracking the satellite were discussed.

After approval of the design, we commenced construction of the first prototype Terminals. Less than four months after award of the contract we successfully transmitted the first signals through the satellite. In fact, we had to wait awhile until the satellite had been moved to its final location over the Pacific under the control of the NASA tracking station at Kokee: Park in Hawaii.

The two prototype Terminals were completed in late 1990 and shipped to Honolulu. A team from MAS visited Hawaii to install these terminals on their permanent rooftop sites and to run a training course for installation and operation of the Terminals. (See Figure 10)

Figure 10: Terminal being lifted on to the roof of University of Hawaii building during installation by MAS

This course lasted one week and was attended by staff from about 15 Island locations. It was quite a challenge conveying the technical intricacies of the system to the participants, who in many cases did not have English as their first language and had never seen an Earth Station before. (See Figure 11)

Figure 11: Attendees at the PEACESAT training course in Honolulu

The entire contract for the first 27 Terminals was completed by early 1991.

Despite initial concerns about the ability of users to maintain this advanced equipment in operation the Network has operated very successfully for some time and has been steadily expanding. MAS has built approximately 15 more Terminals beyond the original contract and we are expecting orders for up to 24 more. We have been carrying out tests on upgrading the network to 64 kilobit per second digital operation in conjunction with Paradise Datacom, one of our principals.

MAS has taken demonstration Terminals to events such as the Pacific telecommunications Conference in Hawaii last year, and the Alternative Satellite Communications Conference in Japan earlier this year. (Sec Figure 12, Figure 13, Figure 14).

Figure 12: Demonstration terminal being erected by MAS at satellite conference in Sendai, Japan

Figure 13: Demonstration terminal being erected by MAS at satellite conference in Sendai, Japan

Figure 14: Demonstration terminal being erected by MAS at satellite conference in Sendai, Japan

The PEACESAT contract was also recognised with a Trade Development Board export commendation award last year. The experience gained in satellite communications has enabled us to competently and successfully bid for a number of contracts in Asia, the Pacific and South America.
I hope this provides an example of what a New Zealand electronics company can achieved. We are also achieving similar export successes with other specialised products such as aeronautical communications and military remote demolition equipment.