A Historical Perspective on WRESAT, the First Satellite Launched from Australian Soil

Allan Forbes
Retired Electronic/Software Engineer

Abstract: Just over fifty years ago, on 29 November 1967 at 2:19 pm (local time), a small scientific satellite named the **W**eapons **R**esearch **E**stablishment **SAT**ellite (**WRESAT**) was launched from Woomera, South Australia. It had been designed and constructed by engineers, scientists and technicians from the Weapons Research Establishment, Salisbury, South Australia; it had a payload of scientific instruments put together by the Physics Department at Adelaide University; and it was sent into orbit at the sharp end of a modified Redstone rocket, a gift from the United States. All of this was achieved in less than 12 months; and it made Australia the third country in the world to launch a satellite into space from its own territory, after the USSR and the USA. This paper is the author's personal account of his part in the project, where he was involved first with the satellite's telemetry system and then with a temporary extension to Oodnadatta of Woomera's flight safety system. The paper goes on to describe events following the successful launch, and the celebration of the 50th anniversary in 2017. Finally, there is a discussion of the politics and technologies behind WRESAT.

Keywords: Satellite, WRESAT, Telecommunications, Woomera

Introduction

This paper provides a review of the history of the launch of Australia's first satellite and how it came to be. This was an exciting time for Australia's new space and electronics industries and the satellite launch highlighted the successful partnership between Defence and the University of Adelaide.

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Recruited into Telemetry

In the mid-1960s, I was a recently graduated electronic engineer and I had found work in the Telemetry Systems Group at WRE Salisbury – the former Weapons Research Establishment, situated near Salisbury, South Australia. Over the years WRE has evolved into the present-day DST Group Edinburgh.

Telemetry can be described as the automatic measurement of things remote or inaccessible, and the transmission of the measurements to a device for recording or display; and in this case, the things remote or inaccessible were generally attached to missiles undergoing flight trials at Woomera. Here is a very brief outline of how the telemetry used to work when I first joined the group:

- During a missile trial, the voltage levels from a few dozen measuring instruments attached to the missile were time-multiplexed into a single data stream, and the data stream was sent back to the range instrumentation centre by UHF radio.
- At the instrumentation centre the received data was demultiplexed to provide quick-look records, for the benefit of missile contractors and others who were anxious to see what might have been happening during the trial.
- The raw multiplexed data was tape recorded, and the tapes were sent to Salisbury for data reduction and analysis.

Among the staff of the Telemetry Systems Group there were electronics specialists who spent their days maintaining and improving the technologies and procedures being employed in telemetry at both Woomera and Salisbury; and I was able to learn something of their craft when I joined them in one of the labs.

We Were Going to Launch a Satellite!

In January 1967, the word got around that WRE was going to build a satellite and launch it from Woomera — which sounded quite interesting.

A very secret lot of trials called Project Sparta had been under way and most of us didn't have a clue what it was all about, because we had no need to know. Security was pretty strict and effective back then when the Cold War was at its hottest. We now know that, under a tripartite agreement, a team from the US, the UK and Australia had been launching modified Redstone rockets in near-vertical trajectories to find out what happened when warheads or spacecraft re-entered the atmosphere at enormous velocities. The Redstone was a liquid-propellant rocket with a very good reputation for reliability, and a few years previously it had been used in Project Mercury to launch first monkeys, then the first seven American astronauts, into space. With second and third stages fitted, one of these rockets would stand about 22 metres tall.

For the Sparta project, a batch of ten modified Redstone missiles had been sent over from the US and, with the success of every one of the nine planned launches, there was a spare launch vehicle just lying there, unused.

Australians high up in the Defence hierarchy had a few ideas about how this rocket could be used, and their hints were not terribly subtle. After all, mate, if it's going to be shipped back to America, it will probably just end up on a scrap heap, won't it? Well, the Americans gave us the spare Redstone; they gave us the services of the launch team; and they undertook to have the inertial guidance system reprogrammed for a satellite launch. Our masters in Canberra found some petty cash to pay for building and launching a satellite – it would be a nice, cheap way of gaining some international prestige, and there might even happen to be a few spin-offs for Australian science and defence.

The satellite was going to be called the Weapons Research Establishment Satellite (WRESAT). The goals could be summarised as:

1. To extend the range of scientific data relating to the upper atmosphere;
2. To assist the US in obtaining physical data of relevance to its research program;
3. To develop techniques relevant to the launching trials in the ELDO (European Launcher Development Organisation) and British satellite programs;
4. To demonstrate an Australian capability for developing a satellite using advanced technology and existing low-cost launch facilities at Woomera.

It didn't take long for the project to get under way. People from all over WRE, myself included, found themselves contributing to the project from time to time and then going back to ordinary work. The satellite itself was being designed and built by WRE and the experiments going up in it were being provided by the Adelaide University Physics Department, where there was a long history of upper atmospheric research using locally developed rockets.

Telemetry for WRESAT

The basic NASA system

My particular contribution to the project started at one of the Telemetry Systems Group meetings, when I was handed a NASA booklet with a title that went something like 'Telemetry Format for Small Scientific Satellites'. I was asked to study this document, have some thoughts about what could be done for WRESAT, and report back.

The booklet described the signal processing steps to be followed when you had a few dozen instruments on board such a satellite and you wanted to transmit the measurements back to earth for subsequent data analysis. It didn't take me long to see that the NASA telemetry system had a lot in common with the one we were using at Woomera and which I had come to understood in some detail. The two systems used the same modulation techniques for data multiplexing, encoding and transmitting, and the main differences could be described in terms of some scale factors. By scaling the number of data channels, a few encoding parameters and the downlink frequency, you could, in theory, have converted Woomera telemetry to NASA telemetry, or NASA telemetry to Woomera telemetry.

At that time, NASA had a system called STADAN, the ‘Spacecraft Tracking and Data Acquisition Network’, which received, recorded and processed telemetry data from an experimental satellite and calculated the satellite's orbital parameters. In addition, universities and other research organisations around the world had their own NASA-compatible satellite receiving stations and they were prepared to tape record other people's raw telemetry data and send the tapes back to the experimenters by courier or parcel post.

The Woomera ‘Type 465’ telemetry…

The system being used at Woomera, and with which I was now familiar, had been developed in the 1950s at the Royal Aircraft Establishment, Farnborough, UK. It was called ‘Type 465’, presumably because it transmitted on a nominal frequency of 465 MHz.

A telemetry kit on board a missile included a small electric motor, called a switch motor, spinning around at about 50 revolutions per second, to drive a simple 24-segment commutator. Twenty-three of the commutator segments, for data channels, were connected to measuring instruments such as strain gauges and accelerometers; and the 24th segment, for the sync channel, was connected to a special DC voltage that would stand out like a sore thumb from any of the sampled data voltages.

The common signal output from the switch motor was sent off to a frequency-modulated subcarrier generator, to produce subcarrier frequencies varying over the range 130 to 160 kHz for the data channels and fixed at 180 kHz for the sync channel.

The subcarrier then amplitude-modulated the missile's nominally 465 MHz UHF signal; and the amplitude modulated UHF signal was transmitted to receivers on the ground.

At the range-head instrumentation centre, the frequency-modulated subcarrier was detected, and tape recorded for analysis back at Salisbury. For the quick-look displays required by technical and contractor personnel, further processing was performed in real time to extract instrument readings and send them off to display devices such as chart recorders.

Until early in the 1970s, the active components of a missile's telemetry equipment would generally have been designed around thermionic valves and electromechanical devices. By the standards of the day, it was described as sub-miniature. To stop the batteries from going flat during pre-launch preparations, a missile would be connected to an external ‘shore’ power supply until just before launch; and after launch, battery drain would not be such an issue because of the missile's very limited life expectancy.

Telemetry parameters for WRESAT

The satellite telemetry system described in the NASA booklet transmitted in the 136-138 MHz band — which is still being used for satellite telemetry but with frequencies below 137 MHz now deprecated.

As with the '465' telemetry system:

- The data voltages from multiple and independent data channels were time-division multiplexed into a pulse-amplitude-modulated data stream, with a unique data voltage set aside for the sync channel.
- The time-division multiplexed data was used to frequency modulate a subcarrier.
- The transmitted VHF radio signal, in the 136-138 MHz band, was amplitude modulated by the subcarrier.

When I studied the booklet's signal parameters I came to the conclusion that the design was quite conservative and I was certain that I could make better use of the available bandwidth. With some tweaking of the number of channels, the sampling rate and the subcarrier frequencies, I arrived at a compatible alternative design offering a tenfold improvement in data collection rates and without compromising data accuracy. I can't remember the exact details of what I designed; but I think there were about 20 channels, each sampled about 20 times a second. The details might be buried in a research paper somewhere.

It wasn't long before I was told that my design had been accepted and that the details had been passed on to the satellite instrumentation contractors in the United States.

The WRESAT Ground Station

I was asked to go ahead and develop some ground station equipment that would give us an idea of what was going on in our satellite while it was up there in orbit. What we needed was something that would take the telemetry subcarrier coming in through a VHF radio receiver, demodulate the subcarrier to give a copy of the sampled data stream, and then demultiplex the data stream to recover instrument readings. Watching what was happening in real time on an oscilloscope would give an indication of whether the satellite and its instrumentation were still in good health.

The first step towards developing the ground station was putting together a sort of bench-top satellite simulator – an assembly of electronics that produced a frequency modulated subcarrier, driven by a repetitive stream of pulses representing the output from a sampling switch. The thing was no joy to behold, but it did the job.

My design was based on current, state-of-the-art electronics – which, at the time, involved components such as matched pairs of silicon transistors, and inductors wound on special ferrite cores, all of it soldered onto circuit boards with connecting wires at the back and plugged into a card tray. For some parts of the ground station, I was able to call on existing designs from our 465 telemetry replay equipment and, for other parts, I had to work it out for myself, more or less from first principles.

It took about six weeks, with a fair bit of overtime, to get all of this to a state where a draughtsman could produce detailed drawings. A radio tradesman assembled the final product into a neat and professional-looking bench-mounted box and it worked perfectly.

What Other Groups Were Doing

As the months went by, we shared our snippets of WRESAT news around the tea trolley. Here are some of the things we were hearing about and discussing:

- The mechanical engineers had received the design requirements for fitting a satellite to a Sparta vehicle. They had designed and built a model of the satellite and had performed spin tests to determine its dynamics – because when the satellite reached orbit, the experiments required it to be spinning at a particular rate and on a particular axis.
- The satellite model had been subjected to vibration testing – I think it was something like 30 or 40 G at frequencies up to about 20 Hz. You don't want a satellite's bits and pieces rattling around inside while it is being launched.
- The satellite and its instrumentation were being put through extensive laboratory testing.
- The radiation pattern of the telemetry aerials had been measured out in the Aerial Test Field.
- Explosive bolts had arrived. They were going to secure external panels and the nose cone during launch; and when the satellite reached orbit they would pop to jettison the panels and nose cone and expose the experiments.

And in between WRESAT work, most of us continued with our more normal activities.

Range Safety for the Launch

The requirement

In August 1967, I temporarily joined the team responsible for WREBUS, the Weapons Research Establishment Breakup System. It was a part of the flight safety system that blew up missiles when they strayed off course or got out of hand. During a missile flight trial, the Range Safety Officer kept an eye on where the thing would impact if its propulsion system were to cut out; and if the predicted impact point came too close to the edge of the designated safety corridor, he pressed his Big Red Button; coded radio signals were transmitted to the missile; and a small explosive charge was detonated to break it up, with the debris coming down inside the safety corridor.

Because radio waves can be severely attenuated when they pass through a rocket's exhaust plume, the WREBUS system at Woomera was equipped with two separate transmitters, separated geographically and separated in frequency, but transmitting identical codes. This was to ensure that a missile would always be able to receive the codes, regardless of its heading. The missile's receiving system listened simultaneously on both frequencies; and if reception on one of the frequencies faded away because of flame attenuation, there would still be good reception on the other frequency.

But with the WRESAT launch there was a problem – when the second stage motor ignited, up in the sky and far away, the exhaust plume was going to cut off the signals from both transmitters back at the launch site. It was a matter of simple geometry. So a third transmitting station was needed at a location well away from the exhaust plume's line of fire. The chosen spot was Oodnadatta, and two WREBUS transmitters, one for each frequency, were going to be installed in a portable caravan located next to the airport runway.

The Oodnadatta WREBUS station had to be integrated into the Woomera range safety system and controlled remotely from Woomera It had been decided that the most practical way of achieving this was to send control signals between Woomera and Oodnadatta simultaneously over a landline and two shortwave radio channels. Sending the same signals simultaneously over three separate and independent channels would improve reliability.

The distance from Woomera to Oodnadatta is about 410 km as the crow flies. The two chosen radio channels were normally used for voice communication between Woomera and the Giles weather station in Western Australia, and they wouldn't pose much of a technological problem apart from the inevitable noise, interference and fading that's to be expected with high frequency ionospheric radio. But the landline was another matter. Telephone lines through the bush between Woomera and Oodnadatta might have existed, but you really can't use party lines strung between gum trees in a prime safety system. So the PMG's Department did their best for us by patching together a 6000 km detour along the nation's trunk telephone network. It went south from Woomera to Adelaide; eastwards across Victoria; up the coast, probably as far as Rockhampton; inland across Queensland and the Northern Territory to Tennant Creek; and south through Alice Springs to Oodnadatta. At Oodnadatta it took out one of the three lines going into the town, to leave only two lines between Oodnadatta and the outside world.

In the Instrumentation Building at Woomera there would be a pair of wires coming from the Safety Officer's push button; and at Oodnadatta there would be another pair of wires going to the WREBUS transmitters in the caravan. My job was to put together some electronics that would behave like a solid, reliable, 410 km long pair of wires joining the Woomera push-button to the Oodnadatta transmitters. For this, I had to use a combination of two channels of high frequency ionospheric radio, which is a technology notoriously subject to noise, interference and fading, along with a ridiculously long landline, which also could be prone to noise and interference but hopefully not to the same extent as the radio channels.

Signalling by wire and wireless

I spent a few weeks in the lab trying out some ideas. When I had a working prototype the circuit diagrams and construction details were drawn up by a draftsman and a radio tradesman did a very nice job of putting it together. It all fitted into two small bench-top equipment cabinets, one of them for the Woomera Instrumentation Building and the other for the Oodnadatta caravan.

I had devised a scheme in which the current state of the Safety Officer's button was sent over the link in short coded messages, repeatedly and continuously. There were just two messages, which I called respectively 'Prohibit' and 'Fire'. 'Prohibit' was sent out over the link four times a second while the Safety Officer's finger was away from the button; and 'Fire' was sent out two times a second while the Safety Officer was pressing the button. English translations of the coded messages would have gone something like this:

- **Prohibit** – 'The Range Safety Officer is not pressing the button, so please refrain from keying the transmitters on for the next 2 seconds'.
- **Fire** – 'The Range Safety Officer is now pressing the button, so please key the transmitters on immediately and destroy the missile'.

The 'Fire' message code was twice as long as the 'Prohibit' code, and more complex, because receiving and decoding a false 'Fire' command would have had much more serious consequences than receiving and decoding a false 'Prohibit' command.

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I transmitted the message codes using three electrical signalling levels – two levels to carry binary data for 'Prohibit' or 'Fire', and the third level to provide clock pulses for the shift registers used in the decoders at the Oodnadatta end. I figured that the decoders might need all the help they could get as they struggled to detect recognisable patterns among the interference and other rubbish coming in over the air waves and the telephone system. I had a feeling that a phase-locked loop might keep dropping out when the going got rough.

At Woomera, the three-level pulse stream generated from the state of the safety button was fed to a frequency modulator, to produce an audio-frequency subcarrier occupying a band of about 300 Hz to 3000 Hz – this made it compatible with voice communication plant. The subcarrier was then sent on its way, simultaneously, over the two high frequency radio channels and the 6000 km landline.

At Oodnadatta, the signals coming in over each of the three channels were examined individually and independently, to see whether there might be any 'Prohibit' or 'Fire' message codes detectable among the noise and interference. For each channel the received signal was sent to a frequency demodulator, or discriminator, to produce what would hopefully be a filtered three-level pulse train. If the signal amplitudes from the demodulator fell within acceptable limits, clock pulses were extracted to move the demodulated binary data through a system of shift registers, and logic gates detected the presence or otherwise of 'Prohibit' and 'Fire' codes. Whenever a valid code was detected, the appropriate control line feeding to the transmitter system was latched to its 'Code Received' state; and if another code of the same type was not received within a certain time interval – 2 seconds for 'Prohibit' codes – the latch would be automatically reset to its 'No Code Received' state

Until the transmitters were armed and ready, the terminal equipment at Oodnadatta would be doing little other than working away at receiving and decoding signals coming in by radio and landline. It had a display panel with lamps to show the status of the three communication channels and there was a loudspeaker to let you hear what was coming through on the radio channels and the landline. The loudspeaker was also part of an intercom that could be switched into the landline back to Woomera, temporarily interrupting the flow of message codes.

The transmitters remained disabled until the officer in charge armed them with keys that he otherwise kept safely in his trouser pocket; and once armed and ready, the transmitters gave ample warning of their status with buzzers and flashing lights. It was all quite dramatic.

With the transmitters armed and ready, the only thing that could stop them from going on air was the continuous arrival of 'Prohibit' codes no more than two seconds apart. They were being sent from Woomera at the rate of four a second, simultaneously over three channels; and if conditions were to deteriorate to the extent that nothing recognisable could be decoded at Oodnadatta for more than two seconds straight, it would be an indication that the overall link had failed and the transmitters would be keyed on automatically to destroy the missile. This was in line with the mandatory fail-safe policy for this sort of safety system. If ever control of the command breakup system were to be lost during a flight trial, the system had to take over automatically to cut the missile down and avoid the risk of having it stray outside of the safety corridor.

And when the transmitters were armed, a single 'Fire' command coming in over a single channel would be sufficient to key the transmitters on and destroy any WREBUS-enabled missile within radio range.

I knew I had to get the design right.

Installation and Field Testing

A lot had to be done ahead of the launching and a team of about half a dozen of us spent various amounts of time at Oodnadatta to set up all the gear and check it out. When I arrived for my stay of about two weeks, the radio masts were up and the caravan was in position and largely operational. Over several weeks of field testing, sometimes with severe interference on the radio channels along with crackling and cross-talk on the telephone line, the link from Woomera to Oodnadatta didn't fail a single time. Every 'Fire' command sent from Woomera was received promptly and there were no dropouts lasting long enough for a failure event to be triggered.

Designing, building and commissioning the Oodnadatta station had taken us only 10 weeks.

The Satellite Launch

Countdown preparations

About a week before the scheduled launch date I had to travel to Woomera, where I was to be the WREBUS operator at the Woomera end of the link to Oodnadatta.

The Woomera part of my equipment had been installed on a bench in Room 4, the Hazardous Circuits Room of the Woomera Instrumentation Building. The room had racks full of equipment associated with the launching of missiles, and it was the domain of two highly reliable and experienced operators. During any trial the door was kept locked from the inside to guard against any interruption or interference. That's where I would be stationed for the WRESAT launch.

Figure 1. WRESAT on the launch pad (Source: [DSTO 2018])

I was given a copy of the trial instructions for the WRESAT launch – it was a long document with a numbered list of the many actions and procedures to be followed during the count-down. In the days leading up to the launch there were several rehearsals and anybody with a part to play, including the Oodnadatta crew, had to be standing by, ready to respond over the intercom network whenever the count-down reached an item for which he or she was responsible. The intercom between Woomera and Oodnadatta was connected over the 6000 km landline, and the terminal box at each end of the line had a switch for manually swapping between data transmission and intercom. The count-down involved a lot of systems, subsystems and personnel – there must have been a cast of hundreds – and a summary of systems would have included launch vehicle preparation, payload preparation, telemetry, range safety, optical tracking, radar tracking, and more.

The count-down rehearsals were conducted at quite a rapid pace, and in some parts of them hours of count-down time were compressed into just minutes of rehearsal time. But the real count-down on the day of the launch was to start, as I recall it, at about 4 in the morning, and keep going until ignition and lift-off at about 2:19 in the afternoon.

During the rehearsals, my own small parts in the count-down had me acknowledging that I was present at my post in Room 4, and that my end of the link to Oodnadatta was working. And when the Oodnadatta crew received their cues over the intercom, they were able to acknowledge that they were present, that the link was working normally at their end, and that their transmitters were operational and standing by.

When the time came for the satellite to be mated to the launch vehicle, the Americans were horrified when they saw it being brought along on the back of a ute. They were used to keeping payloads like that wrapped in cotton wool until the last minute. The Australian response went something like: 'Well, if it has to survive a ride on top of that monster of yours, we reckon a ride on the back of a ute isn't going to do it too much harm'.

The launch was supposed to take place on Tuesday, 28 November; but the countdown on that day had progressed to less than a minute before ignition when there was a call of 'Stop Stop Stop' and the trial had to be aborted. An air-conditioning unit had failed to detach from the upper parts of the missile.

Ignition, Liftoff and Orbit

On Wednesday, 29 November 1967, everything went smoothly. As set down in the Trial Instructions, when the countdown reached zero and I heard the announcement of 'Ignition' over the public address, I repeated 'Ignition' over the intercom to Oodnadatta and I received their acknowledgement. Then, at +23 seconds and right on schedule, I heard and repeated the announcement of 'Lift Off'.

Oodnadatta acknowledged Lift Off, and at both ends we switched the landline from intercom to data. My 'Prohibit' commands started flowing from Woomera to Oodnadatta. At Oodnadatta, keys were turned in locks to arm the transmitters; and after the designated time interval, the transmitters were disarmed again. We crossed our fingers, waiting to see what was going to happen.

Back at Woomera we were being given a running commentary over the public address as the launch progressed. About 6 minutes after lift-off we were told that WRESAT was in orbit. I got onto the Oodnadatta intercom as soon as I could to tell them the news, and I think I sounded more than a bit excited.

A hundred minutes later, at around 4 o'clock in the afternoon, I was standing next to my ground station equipment in the Instrumentation Building, watching telemetry data coming in from WRESAT. Our satellite was a few thousand kilometres away over the Indian Ocean, off the West Australian coast near Carnarvon, and it was heading towards the North Pole at the start of its second orbit.

A short excerpt of a documentary that includes the WRESAT launch is available on YouTube (2012).

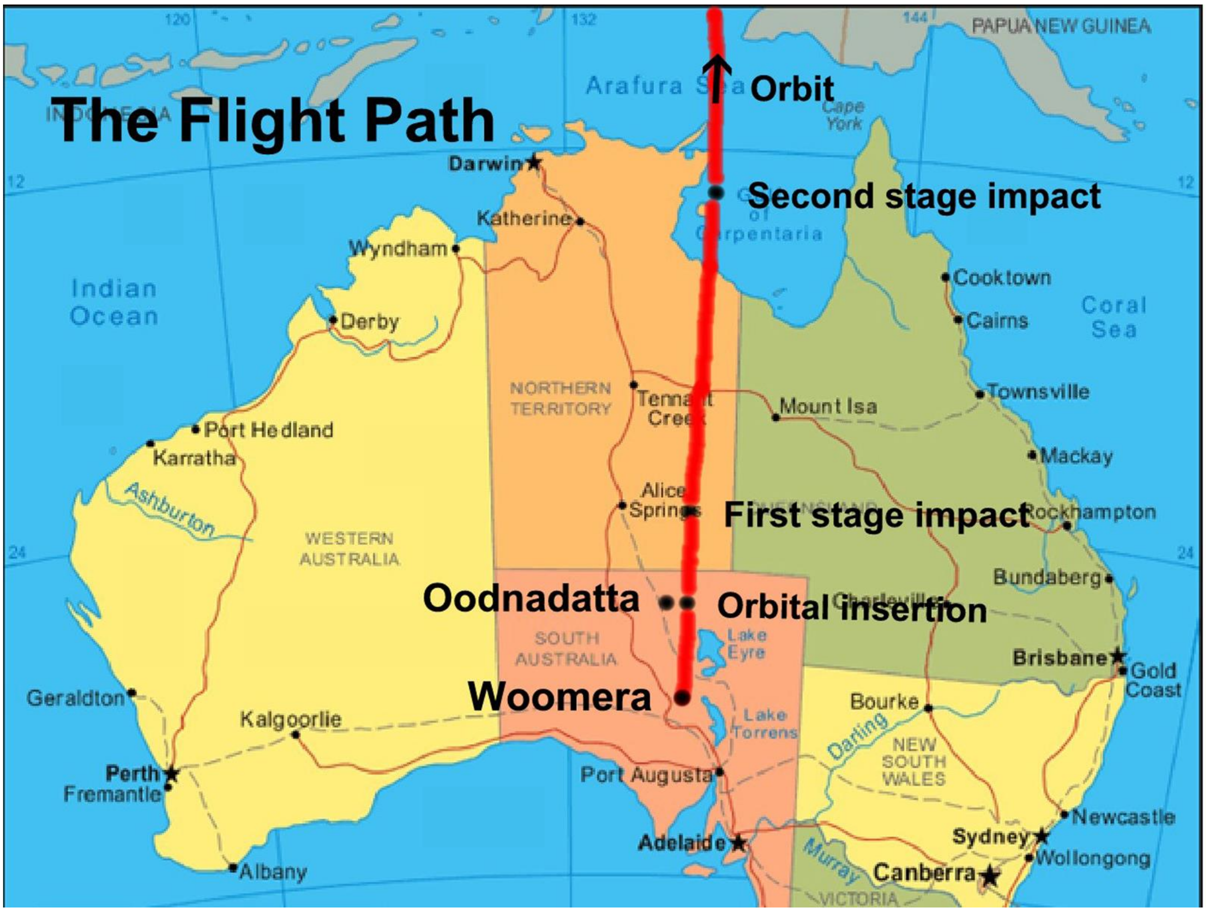

Figure 2. The WRESAT flight path

That night we had a tremendous party back in the Woomera Senior Mess. I'm afraid I was one of the young fellows at the back of the hall, from where we were carrying on with great glee and gusto while a succession of VIPs up front were doing their best to congratulate us all.

Until one of the satellite's batteries went flat four-and-a-half days later, a bit sooner than expected, ground stations from all around the world kindly recorded WRESAT telemetry signals for us and sent us their tapes. I wonder how many PhDs were generated from that data?

WRESAT re-entered the Earth's atmosphere on 10 January 1968, after 43 days in orbit, and it burnt up over the Atlantic Ocean to the west of Ireland. In 1990 the wreckage of the Redstone first stage was found in the Simpson Desert. It was returned to Woomera, where it is on permanent display.

In the News

For a week or so after the launch, news about WRESAT was hitting the headlines world-wide. Australia had joined the USSR and the US to become the third country in the world to design and build its own satellite and launch it from its own soil. This had been achieved in the impressively short time of eleven months, and it had placed Australia among the world leaders in space technology.

Work associated with WRESAT continued sporadically for a few more months with meetings, reports, papers and presentations. Such was the interest in space technology that the WRESAT prototype was exhibited in Parliament House, Canberra; then at the London Trade Fair in 1968; and in various museums and galleries around Australia.

Here is my unofficial assessment of the project's achievements, in the same order as the list of project goals:

1. The range of scientific data gathering, relevant to the upper atmosphere, had been extended, to the extent that data collected during 4½ days of low-earth orbit would have augmented similar data collected by high-altitude sounding rockets.
2. This small battery-powered satellite could not have contributed very much to the massive US research program, when data could be collected for only 4½ days.
3. During preparations for the WRESAT launch it had been shown that it was safe to carry a small conical satellite to its launch site on the back of a ute. Would this be seen as a technique relevant to the launching trials in the ELDO and British satellite programs?
4. WRESAT had indeed demonstrated an Australian capability for developing a satellite using advanced technology and existing low-cost launch facilities at Woomera.

Fifty Years Later

The Australian Government had for fifty years shown no interest in developing a home-grown Australian space industry, and WRESAT had no successor. The only other satellite launched from Australian soil was Prospero, a British research satellite launched from Woomera in 1971 using a Black Knight rocket. While there have been other Australian satellites that were designed and built in Australia, they have not been actually launched from Australia.

Then, in September 2017, the Government expressed a renewed interest in space exploration. During the 68th International Astronautical Congress held in Adelaide, it was announced that Australia would create its own space agency in an attempt to cash in on a $420 billion aeronautical industry, and it would create thousands of new jobs. Australia was the only OECD country without a space agency.

To coincide with the Astronautical Congress, an exhibition of space-related memorabilia from Woomera had been set up in the State Library of South Australia, with an emphasis on high-altitude sounding rockets and WRESAT. In one of the glass cases, there was a prototype of the WRESAT telemetry encoder, constructed from rectangular pieces of perforated fibreglass board and bolted together into an assembly about the size and shape of a loaf of sandwich bread. The topmost circuit board had a row of rather large, gold-plated, antique, integrated circuits, and the other boards were packed with electronic components and neat bundles of

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wiring. Nowadays, the same functionality could be designed and built into a single chip the size of a postage stamp.

Officials from the Department of Defence in Canberra had managed to track down just a few of the original WRESAT team, from other organisations as well as from WRE, and had invited them to a special 50th anniversary celebration at the State Library of South Australia. It was to take place while the Astronautical Congress was still in progress. The event was held in a lecture theatre next to the space exhibition, and the WRESAT veterans were greeted by Members of Parliament, the Chief Defence Scientist, and other notables. After some speeches, the veterans were paraded one by one to be presented with souvenirs that included a framed certificate and a medallion. Afterwards there were some interviews with the ABC: excerpts from the interviews kept popping up in radio documentaries and news broadcasts for several weeks.

The Significance of WRESAT

What is the overall significance of WRESAT? The principal motive for building an Australian satellite and launching it from Australia must have been political, with the aim of gaining international praise and prestige. The amount of scientific data to be collected would have been of secondary importance, but it was important that WRESAT be seen as a real scientific satellite. A goal like 'Assist the US in obtaining physical data' must have been more about politics than science. When it was a success, Australia suddenly joined the world leaders in space technology, but was quickly overtaken when the government showed no further interest. WRESAT was virtually forgotten for nearly 50 years, until some old hands lobbied successfully for its memory to be revived in a series of celebrations. WRESAT is a memory of a short-lived glorious past, with little relevance for the present or the future except as an inspiration to show what might be achieved.

The activities and outcomes from WRESAT hold little continuing value:

- Significance for science: Little. In the overall scheme of things, the quantity of data collected was very limited because of the limited life of the batteries. The data probably would not have added significantly to any extended statistical database of the phenomena being observed.
- Significance to the development of rocketry: None. The launch vehicle was of a mature design and very reliable.
- Significance for the development of telemetry: None. There was nothing revolutionary in the telemetry system: it was just the application of a few scale factors to a generic design. Over the years the technologies and data encoding schemes for satellite telemetry have changed enormously. NASA now has readily accessible websites

offering a lot of useful information, some of it in tutorial form, for anybody wishing to design a telemetry system, for almost any type of spacecraft, and for almost any type of space mission.

- The Woomera-to-Oodnadatta control link. With the high-quality telecommunication services now in place across most of Australia, setting up a reliable control link across a few hundred kilometres of the Australian bush should never again require such an eclectic mixture of borrowed shortwave radio channels, thousands of kilometres of landline patched together from the national telephone network, and a paranoid coding scheme.

Conclusion

This paper has described just two of the technical challenges that were overcome to make WRESAT a success. In the big picture of space exploration, WRESAT was a one-off, opportunistic adventure into space technology that turned out to be successful. Apart from serving as an historical case study and an inspiration to show what can be achieved, any experience gained fifty years ago would have very little impact on an Australian space industry in the 21st century.

But it was fun while it lasted.

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