# 36MHz Studies

**14, 26 & 29 August 2019**

**Greg Egan,** MIEEE, MACM, MBCS, FIET, FIEAust (Ret.), CPEng, CITP
**Peter Cossins,** MIEAust (Ret) SMIREE (Ret)
**Ray Cooper**

## Summary Observations

This report should be read in conjunction with a previous report [1]. Testing concentrated on the 36MHz Band using only full range 36MHz implementations from JR.

The interference performance of the 36MHz equipment used is, if anything, better at Mount Hollowback than in the urban environment of the VARMS Flying Field.

2.4GHz Band reference flights limited by conditions, were conducted to the North and West of the Tower Complex and while lower than observed previously remain unacceptable to the West and we believe the Western Peak as a whole. No interference has been detected to date on the Eastern Peak.

From the noise floor measurements taken, the use of the 900MHz band offers the prospect of reliable performance if included under the MAAA Insurance arrangements. Equipment in this band has been quite readily available for several years and is in use in Australia.

# 1. Background

It is assumed that the reader is familiar with the material presented in the 2.4GHz Report [1].

The tests apply only to full-range transmitters and receivers. This explicitly excludes "park-fly" equipment intended for aircraft around 100gm and 36MHz equipment using a base loaded short antenna.

Testing focuses on measuring **failsafe** events or hits for failsafe equipped receivers and **glitch** hits for PPM receivers.

For those receivers with failsafe it is important to set the failsafe appropriately and to reset them after trimming. The default use of hold last control setting may not be appropriate for slope flying where failsafe hits may occur in a high banked turn for example.

Much of the detail of the results is presented in the Appendices:

A: Receiver Behaviour Logging
B: Mount Hollowback Tests
C: VARMS Flying Field Tests
E: Frequency Bands and Noise Floors

# 2. Equipment

### 2.1 Noise Floor

The noise floor was again measured using a Protek 3290 RF Signal Strength Analyser (Appendix D).

### 2.2 Aircraft

1. MultiPlex Xeno (flying wing) pusher prop, running on 3S 1300mAH battery. Both 36MHz receivers where mounted in the wing, outboard of either side of the main fuselage area, with their respective antenna routed out along the wings to the tips. The 2.4GHz Transceiver was located in the nose alongside the logger board. *The 2.4GHz Transceiver was also used as a data down link for real time "Failsafe" and "Glitch" count information.*

2. Southern Sailplanes Prelude, 2 channel glider. Standard receiver/servo installation with antenna routed down to rear of fuselage.

### 2.3 Controlling Radio Equipment

1. JR 3810 Transmitter (SPCM) with JR RS77S Receiver (SPCM). Frequency 36.17MHz. Failsafe set to neutral aileron, elevator, motor off and gear channel to high position. Gear channel monitored by Logger to record failsafe hits.

2. JR PCM9Xii Transmitter (PPM) with JR R700 (PPM) and JR NER-326X (PPM) receivers. Frequencies 36.25/36.17MHz, respectively. Gear channel monitored by Logger to record glitch hits.

### 2.4 Monitored Radio Equipment

1. There were two monitoring configurations for these aircraft:
   - JR PCM9Xii Transmitter (PPM) with JR R700 Receiver (PPM). Frequency 36.43MHz. Gear channel monitored by Logger to record glitch hits.
   - FrSky Taranis Transmitter and FrSky D4R Transceiver. Frequency 2.4GHz. Channel 1 monitored by Logger to record failsafe hits. *Note: The monitored equipment was not controlling the aircraft.*

2. Monitored radio was the (PPM) controlling equipment.

## 3. Testing

The full details of the various noise floor measurements are contained in the Appendices.

### 3.1 Mount Hollowback Tests

Wind conditions prevented flights other than to the North and West of the Tower Complex.

*3.1.1 Noise Floors*

The noise floor within 20 metres of the towers was observed as -86dBm @ 36MHz and -70dBm @ 2.4GHz. Higher fluctuations of 2.4GHz were noted in relatively short bursts.

Close to the flight line on the Northern Slope it was -90dBm @ 36MHz and -60dBm @ 2.4GHz. Note that the noise floor was higher on the slope for 2.4GHz, most likely due to catching one of those transient fluctuations noted above.

*Note: Measurement of the noise floor of 915 – 928MHz at Hollowback was found to be significantly lower than 2.4GHz and similar to that measured on 36MHz.*

*3.1.2 Flights*

For the two flights using the Xeno to the North there were 3 PPM glitch hits with a maximum duration of 0.4 seconds and no failsafe hits on 2.4GHz. There was 1 SPCM failsafe hit recorded but that was due to an inadvertent selection of the gear switch (See Appendix B).

For the PPM flight to the West of the Tower Complex there was one PPM glitch hit with maximum duration of 0.4 seconds.

For the two 2.4GHz flights to the West of the Tower Complex the number of failsafe hits and durations were 4 hits maximum period 2.2 seconds and
3 hits for 1.2 seconds.

There were no SPCM failsafe hits for the Western Peak flights.

While lower than previous test we believe 2.4GHz performance remains unacceptable for the Western Peak.

For the three Prelude flights using the PPM JR NER-326X at 36.17MHz and 100M North of the Tower Complex the number of receiver glitches were 3, 2 and 0. The maximum duration was 0.4 Seconds. Flight durations were ~10 minutes.

### 3.2 VARMS Flying Field Tests

#### *3.2.1 Noise Floors*

The measurement, while not taken on a flight test day, is believed to be typical but high for 2.4GHz at -74dBm to -72.5dBm. Some aircraft transmitters were visible within the scan. For 36MHz the floor was -102dBm. Strong signals could be observed on various frequencies however.

#### *3.2.2 Flights*

Flights used the Xeno test aircraft on 36.43MHz.

For the two flights on the 14 August 2019 using the V1 Logger there were 14 and 3 PPM glitches recorded respectively of 0.1 second maximum duration.

For the supplementary flight on the 26 August 2019 using the V2 Logger there were 22 PPM glitches of 0.4 seconds maximum duration.

There were no failsafe hits for SPCM on either day.

As a matter of interest, a further flight was conducted at the VARMS field on 29 August 2019. This time the controlling receiver was a JR R700 **PPM** and in addition a small Key-fob video camera was mounted on the aircraft to view the left hand elevon and propeller to record “glitch” activity. The flight lasted 11.5 minutes with 6 glitch hits recorded by the logger, and a max duration of 0.5 sec.

The video clearly showed the 6 glitches, which included momentary motor start/stop and random rapid elevon movements. None of these where visible to the pilot at ground level. This confirmed the correct operation of the logger.

## 4. Interpretation of Results

The excellent 36MHz SPCM performance requires no qualification. The performance of 36MHz PPM equipment was also, perhaps, surprisingly good.

Performance of 2.4GHz was confirmed as unsatisfactory on the Western Peak.

## References


[1] 'Mount Hollowback 2.4GHz Investigations', August 2-4 2019, G.K. Egan, P. Cossins, R.J.V. Cooper, August 8, 2019, http://varms.org.au.

[2] 'Glitch Counter', https://github.com/gke/GlitchCounter.

## Appendix A: Receiver Behaviour Logging

The long standing convention/standard for R/C equipment has been for receivers to send pulses to each of the output channels within range of 1 millisecond (mS) to 2 mS width. Historically these pulses are repeated every 22mS although there are significant variations to this as newer ideas are implemented. Pulses for neutral control surfaces are nominally 1.5mS wide.

### A.1 Receivers with Failsafe

Once connected before flight 36MHz receivers with failsafe capability (and typical 2.4GHz receivers) have the ability to detect that they are no longer receiving valid information from the transmitter and force their servo output channels to a known state or to simply hold the last state. It is not known whether these detection schemes are perfect as their inner workings are not known to us however we do know it is possible to build receivers that reliably detect interference.

The R770S receiver produces a clean transition to the channel failsafe setting after a delay of 0.25 Sec. It is understood that it simply maintains the last good data during that period.

For the failsafe receivers we check if the failsafe channel pulse width is either less than 0.8 mS in which case the receiver's failsafe detection may have failed or greater than 1.2mS in which case the receiver is deemed to have gone to its failsafe setting. In either case we count this as a Failsafe Hit and increment the count starting the timer. If the pulse width is greater than 0.8mS and less than 1.2mS we stop the timer and use the time to update the maximum failsafe duration if necessary.

### A.2 PPM Receivers

PPM receivers of the type tested have no failsafe capability. They simply pass the information they receive almost directly to the servo/throttle channels.

If the signal from the transmitter is lost or corrupted the receiver can exhibit a number of behaviours from no pulses at all at its outputs to pulses of random width and arrival rate.

We automatically determine the nominal delay between valid pulses on the failsafe channel when the transmitter is first connected. Valid pulses must be between 0.8mS and 2.2mS wide.

Once in flight pulses must arrive within 0.5mS of the nominal delay and be within 0.8mS and 2.2mS wide. If these conditions are satisfied the pulse must also be within 0.8ms to 1.2mS wide. If any of these conditions is not satisfied we deem there to have been a glitch and increment the glitch counter.

Following the glitch we require 20 pulses where all of the above conditions are satisfied. The maximum glitch duration is then updated. In what follows this means the minimum glitch period for PPM as logged is around 0.4 seconds.

It is <u>important</u> to be aware that because of the Logger's limitations we are only monitoring a single PPM receiver channel and there is a distinct probability that glitches will be occurring on other channels. Unlike the failsafe counts for SPCM receivers the glitch counts are therefore conservative. It is however believed that monitoring a single channel and the frame interval is adequate for the purposes of this study.

The logger program is available on gitHub for those interested [2].

## Appendix B: Mount Hollowback Tests

*Flight 1,* Aircraft # 1 - 24 Aug 2019, between 11 am – 12 noon
Zone flown - North
Pilot location – 100M to the North of the towers
Flight duration – 19 Minutes
PPM 36.43MHz Glitch hits – 3, Max duration **0.4 Sec.**
SPCM 36.17MHz Failsafe hits – 0, Max duration **0 Sec.**

This was mostly a gliding flight with some short bursts of motor assist. Altitude ranged from launch height to 200 feet. There was a good period of time spent flying over the North East landing area, as well as in front of the towers. This was downwind of the pilot, with the altitude ranging from low to ½ tower height. There was also an excursion of flight out to the North to approx. 150 metres from the pilot's position. 2 Glitch hits were recorded during motor run periods and the other during glide. These would not be considered a problem. As a note, the turbulence in this wind strength was considered to more of a problem.

*Flight 2,* Aircraft # 1 - 24 Aug 2019, between 11 am – 12 noon
Zone flown - West
Pilot location – 30M South of the Western Towers
Flight duration – 5.5 minutes
PPM 36.43MHz Glitch hits – 1, Max duration **0.4 Sec.**
SPCM 36.17MHz Failsafe hits – 0, Max duration **0 Sec.**

This flight was all motor assisted and difficult to achieve due to wind direction and strength (and turbulence!) The idea was to fly over the western slope area as would be done in a normal slope soaring flight. As said, this was difficult to achieve, however, there where multiple passes close in and in front of the towers, also over the power lines. The single glitch occurred on the North Slope while the pilot was walking back to get into position to fly the western zone.

*Flight 3,* Aircraft # 1 - 24 Aug 2019, between 11 am – 12 noon
Zone flown - North
Pilot location – 70 M to the North of the towers
Flight duration – 6.5 minutes
2.4GHz Failsafe hits – 0, Max duration **0 Sec.**
SPCM 36.17MHz Failsafe hits – 1, Max duration **717.8 Sec.**

This flight was a re-test of the 2.4GHz failsafe problems as experienced on the weekend of 2 – 4 August 2019. The flight profile was at 1/2 tower height over the North East landing zone to the North West corner of the hill and in front of towers. As such, part of the flight was motor assisted. The zero failsafe count highlighted what many have said, that they have flown on days without issues and then the next time out resulted in a crashed model. It is hard to know what packet data traffic is being sent from the towers at any given time. The Failsafe hit on SPCM was the result of knocking the gear switch (to the high position) on takeoff, which was not noticed until after the landing.

*Flight 4,* Aircraft # 1 - 24 Aug 2019, between 12:30 – 2:30 pm
Zone flown - West
Pilot location – 30M South of the Western Towers
Flight duration – 5.5 minutes
2.4GHz Failsafe hits – 4, Max duration **2.2 sec.**
SPCM 36.17MHz Failsafe hits – 0, Max duration **0 sec.**

Again, this flight was a re test of the 2.4GHz failsafe problems as experienced on the weekend of 2 – 4 August 2019. Flight was all motor assisted due to wind direction and strength. It was difficult to maintain the same flight positions as the previous weekend, but failsafe hits were recorded over the western slope and would be enough to bring a model down on 2.4GHz.

*Flight 5,* Aircraft # 1 - 24 Aug 2019, between 12:30 – 2:30 pm
Zone flown - West
Pilot location – 30M South of the Western Towers
Flight duration – 6.5 minutes
2.4GHzMHz Failsafe hits – 3, Max duration **1.2 sec.**
SPCM 36.17MHz Failsafe hits – 0, Max duration **0 sec.**

Flight 5 is repeat of flight 4. This was done with Version 1 Logger, as used on the weekend 2 – 4 August 2019. It was to confirm there was no obvious discrepancies in the firmware versions required to record PPM “Glitches” and “Failsafe” hits.


Flt 1 Nth Slope Xeno


Flt 2 W/Slope Xeno


Flt 3 Nth Slope Xeno


*Flight 1,* Aircraft # 2 - 24 Aug 2019, between 11 am – 12 noon
Zone flown - North
Pilot location – 100M to the North of the towers
Flight duration – 6 Minutes
PPM 36.25MHz Glitch hits – 3, Max duration **0.4 Sec.**

This was a gliding flight in turbulent conditions over the North Slope. The glitch count was minimal and was not noticed.

*Flight 2,* Aircraft # 2 - 24 Aug 2019, between 11 am – 12 noon
Zone flown - North
Pilot location – 100M to the North of the towers
Flight duration – 10 minutes
PPM 36.25MHz Glitch hits – 2, Max duration **0.4 sec.**

A repeat of flight 1 - a gliding flight in turbulent conditions over the North Slope. The glitch count was minimal and was not noticed.

*Flight 3,* Aircraft # 2 - 24 Aug 2019, between 12:30 – 2:30 pm
Zone flown - North
Pilot location – 100M to the North of the towers
Flight duration – 10 minutes
PPM 36.17MHz Glitch hits – 0, Max duration **0 sec.**

The receiver was change out for the JR NER-326X, together with a frequency change to 36.17MHz.

A repeat of flight 2 - a gliding flight in turbulent conditions over the North Slope. A zero glitch count may indicate that this receiver had a better “mute” than the R700.


## Appendix C: VARMS Flying Field Tests

*Flight 1* - 14 Aug 2019 between 2 – 3 pm, wind NNW 5 to 10 knots
Zone flown – SW corner to NW corner and general over field
Pilot location – Pilot box
Flight duration – 10 minutes
Glitches – 36.43MHz PPM **14**, Max duration **.1 sec.**
Failsafe hits – 36.17MHz SPCM 0, Max duration **0 sec.**

Flight was mostly under power with approx. 2.5 min of gliding. Various throttle settings from low to full power. Altitude low to 300’.

*Note: Flight tests in 2005 with a different model and motor setup typically had 50 or more glitch hits. This was a faster and more agile model, and a lot of the “glitches” were noticed in control surface movements and motor speed variations.*

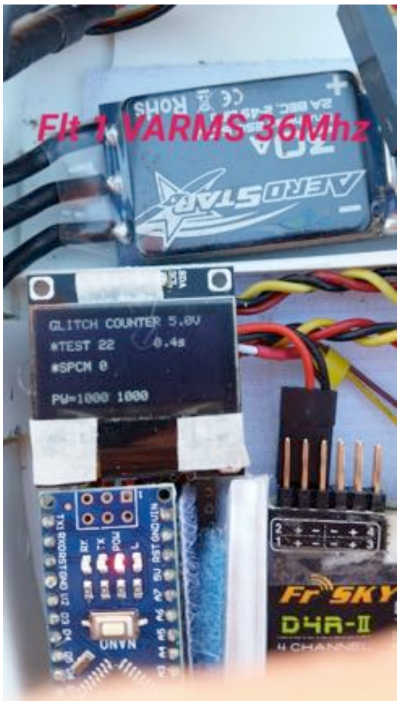
*Flight 2* - 14 Aug 2019 between 2 – 3 pm, wind NNW 5 to 10 knots
Zone flown – W to NW corner and general over field
Pilot location – Pilot box
Flight duration – 3.5 minutes
Glitches – 36.43MHz PPM **3**, Max duration **.1 sec.**
Failsafe hits – 36.17MHz SPCM 0, Max duration **0 sec.**

This was a climb and glide flight. 50 sec of motor run then glide down. The lower glitch count indicated the ESC and motor generate some noise, elevating the on-board general noise floor. Altitude roughly 350’.



*Flight 1* - 26 Aug 2019 between 2 – 3 pm, wind SW 1 to 4 knots
Zone flown – SW corner to NW corner and general over field
Pilot location – Pilot box
Flight duration – 11 minutes
Glitches – 36.43MHz PPM **22**, Max duration **.4 sec.**
Failsafe hits – 36.17MHz SPCM 0, Max duration **0 sec.**

Flight was mostly under power with approx. 2 minutes of gliding. Various throttle settings from low to full power. Altitude low to 400'. Multiple flyby passes over landing strip.



# Appendix D: Frequency Bands and Noise Floors

## D.1 Radiocommunications (Low Interference Potential Devices) Class Licence

There are a number of bands available for spread spectrum or frequency hopping use where there is low potential for interference. Most of the reduction in interference comes from frequency hopping.

*915 – 928MHz*

Available for frequency hopping transmitters with a minimum of 20 hopping frequencies and maximum output power of 1 watt.

One difficulty appears to be that this band overlaps a GSM service operating from 925- 960MHz.

*2.400 – 2.4835GHz*

Currently in common use for radio controlled models and many other uses such as WiFi Modems etc.

*5.725 – 5.850GHz*

Available for frequency hopping transmitters with a minimum of 75 hopping frequencies and maximum of 4 watts (*Outside the range of the Protek Signal Analyser*).

## D.2 Mount Hollowback Noise Floors

The noise floor was again measured using a Protek 3290 RF Signal Strength Analyser set with a bandwidth of 180 KHz. *(It should be noted that the vertical scale is logarithmic).*

The previous investigation [1] used the same setting but used a 2.4GHz 3 element directional antenna which provided modest gain, some directivity and a proper termination for the instrument.

This time, the wideband antenna provided by Protek was used. This antenna provides an omni directional receiving service at right angles to the antenna. (Similar to a model transmitter)

The noise floor within 20 metres of the towers was observed as -86dBm @ 36MHz and -70dBm @ 2.4GHz. Higher fluctuations of 2.4GHz were noted in relatively short bursts.

Close to the flight line on the Northern Slope it was -90dBm @ 36MHz and -

60dBm @ 2.4GHz. Note that the noise floor was higher on the slope for 2.4GHz, most likely due to catching one of those transient fluctuations noted above.


**D.3 VARMS Flying Field Noise Floors**

Noise floor tests were on a weekday afternoon for comparison.

*36MHz*


At the time of measurement, no model aircraft transmitters were active. The 36MHz noise floor at -102dBm is considerably lower than that measured at Mount Hollowback. Strong signals can be observed on various frequencies however. The scan set on the instrument of 36.0MHz to 37MHz was double the frequency allocation for model aircraft so signals in the second half of the screen can be discounted.

*2.4GHz*



The sample scans on 2.4GHz show the noise floor at a high level of -74dBm to -72.5dBm. Some models were flying at the time, with the Signal Analyser only about 15M away. The higher spikes will be due to the model transmitters, but clearly other signals are present also. This demonstrates the very clever nature of frequency hopping technology. Unlike Mount Hollowback, there are no high powered services nearby and certainly not on 2.3GHz. (NBN allocation on Mount Hollowback).

*915 – 928MHz*



A number of signals were noted on this frequency band, but with a noise floor at a very low level of -97dBm to -101dBm. The average signal level is also low and would not present a problem to locally controlled models on this frequency.

Whilst not commonly used by radio control flight this band is used internationally for FPV flight because of its longer range when compared with 2.4GHz.

Our interest here is the potentially greater RF noise resilience it may give.