DragonPlus 2019

An authorised remake of the Compusense Dragon 32/64 add-on from 1985

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What Is DragonPlus?

If you had a Dragon 32 or 64 'back in the day' – or indeed, you discovered the Dragon computer sometime between 'the day' and 'today', then the chances are that you'll find the text and graphical abilities of it somewhat lacking. Ending up almost a clone of the Tandy Colour Computer 1 and 2, the Dragon was built very closely to the Motorola 6809 reference architecture. This enabled the designers of the Dragon to get the computer to market fast – and in comparison to a computer like the Acorn BBC Micro – quite cheaply too.

The Video 'Chip'

The downside of this decision meant that the display capabilities of the Dragon 32 and 64 were defined by the Motorola 6847 'Video Display Generator' chip. Whilst the VDG was capable of running some perfectly good looking games (Frogger, Chuckie Egg etc), it's limitations became apparent when running clones of other games that were in full colour on other machines – for instance, Manic Miner was in monochrome on the Dragon 32, but in 'full colour' on the Spectrum. Even more disappointingly, the Dragon, limited to the 6847's native display capabilities, could not display lower case characters by default. And to add insult to injury, it could only display 32 columns of 16 rows of characters in normal BASIC mode too.

This was the same basic text resolution of the Acorn Atom, a machine released two years earlier.

Whilst the Dragon clearly had a more advanced version of BASIC, more RAM available for programming, and generally more scope, its basic display was still using the very same chip as that much earlier machine, and that was a huge handicap in applications like education or office automation. Even the ZX Spectrum – billed as 'just a toy, suitable for games, but not serious stuff' – had the ability to show lower case characters. The BBC Micro however, the holy grail of microcomputers back in the 1980s, didn't just have the ability to output lower case characters, but had the ability to output at much higher resolutions than any of the competition – like MODE 0 on the BBC Model B, at 80 columns by 32 rows of characters.

```
>RUN
Wow...look at this mode on the BBC, compared to the competition.
It really lends itself to word processing, and other tasks in the real
world.
>
>
```

Software Solutions

Back on the Dragon, some third-party solutions did appear, which attempted to resolve this text display limitation. These were all essentially software solutions though, and whether they ran from cartridge, cassette or disk, were taking up valuable RAM. Not only that, but all of these solutions forced usage of the VDG graphic modes, and therefore took up even more memory. GO51, supplied as part of the OS9 operating system, certainly allowed for more to be viewed on screen, as did Rainbow Writer – but both were slow, and impeded the power of the machine.

The DragonPlus from Compusense

Until 1985, there was no proper solution for the Dragon – which was a shame, as the combination of either Flex or OS9, coupled with the Motorola 6809 microprocessor, offered a powerful business machine. This all

changed with the release of Compusense's DragonPlus add-in board. Although released some time during 1985, the first major review of the DragonPlus can be found in the January 1986 issue of Dragon User.

Back in 1985, the DragonPlus board was retailing for £103.50 plus £1 p&p. That's almost £300 in 2018's money, allowing for inflation – and quite a sizeable chunk of the original Dragon computer's cost a year or so prior.

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Advertised by Compusense as the "Ultimate Expansion For Your Dragon", Roy Coates (of Manic Miner conversion fame) put it to the test for the Dragon User article. Roy takes the reader on a whistle-stop tour of the specifications and fitting of the board, listing it's components as follows:

- 64K of dynamic RAM
- A 6845 Video Display Generator as used in the BBC Micro
- An 8K EPROM containing the character set
- A 2K RAM chip used as screen memory for the 80 columns of 24 rows of text
- The SAM chip from your Dragon
- The [or one of the] ROM chips from your Dragon

It was recommended that a little adhesive be used to secure the board in place, once fitted. This was because the original boards were solely reliant on the SAM socket to hold the board in place.

A brief explanation of the way that the board operates with OS9 and Flex is then given, followed by the conclusion, which it is fair to say is very positive – the main elements being:

- The 80 column display is very, very fast and exceptionally clear.
- The virtual disk gives the impression of using a 'real' system, and offers a lot more flexibility.
- A recommendation that the DragonPlus may be better value for single disk-drive users than a second disk drive.
- The crowning glory of the article "As for the claim that this is the ultimate expansion for the Dragon, well, at the present time there is nothing that compares with it. Add to this Compusense's future plans and their claim may be a genuine one".

It's probably fair to say that the DragonPlus was the last major upgrade available for the Dragon back in the day – although more recently other add-ons have been created (e.g. the Dragon MMC, Coco VGA, Coco SDC and DragonDrive). However, as far as 100% compatible expansions, which will work with original software, the DragonPlus does, to my knowledge still reign supreme.

The Making of DragonPlus 2019

How Did It Start?

I first became interested in the DragonPlus in March 2018, having read much about it on the Facebook Dragon group, as well as browsed the images and details on Simon Hardy's Dragon archive. Quite how I hadn't realised its existence beforehand is surprising, as the Dragon 32 was my first computer back in December 1983 – and I did sporadically buy Dragon User up until May 1986. Anyway – of all of the known add-ons, this one looked like the most interesting – and probably is the most challenging as well.

Having declared my interest in the DragonPlus, and also having seen Tony Jewell's successful efforts with an original DragonPlus board, I felt motivated to try and recreate the boards. I knew that Tony had been in touch with Tad Opyrchal – managing director of the now wound up Compusense, and Tony kindly put me in touch with him.

In communications with Tad, I explained what it was that I wanted to do – and he gave me permission to do so with the DragonPlus – as long as I made it clear that these were modern reproduction boards. And thus the DragonPlus 2019 project was born.

PCB Traces

Having never physically seen or touched an original DragonPlus board, it would have been rather difficult to recreate in the absence of some very useful work that Phill Harvey-Smith had previously undertaken – which was a good set of traces of the copper layout on both sides of the board. Of course, much work was still required, even with these – but it did give me a very good headstart. Also of use were some excellent, close-up images of the board from Rob Owen.

I started with Phill's double-sided trace image – and then in Eagle, started to painstakingly re-create every connection on the board in a new schematic. I'm really pleased that I mentioned this on the Facebook Dragon group though, because at that point Rob Schofield asked me whether I'd considered using KiCad, which was completely free and had none of the limitations I'd encounter with my free Eagle license.

So I downloaded it, and have to say, was rather impressed from the outset. Despite it feeling ever so slightly clunky compared to the slickness of Eagle, it really was totally free, and looked like it would do whatever I needed. The learning curve was, to be honest, huge – though I should, at this point, explain that my first career was in electronic engineering – I did two years working for GEC Marconi – studying for my HNC in Electronic Engineering as well as undertaking an apprenticeship. So I wasn't starting from scratch. But I had forgotten a lot – and certainly, circuit design software back in the early 1990s was nothing like it is now.

Anyway, gradually the trace image became filled with more and more yellow lines – indicating that I'd covered that part – and my schematic gradually built up. At some point along this journey, Phill sent me his Eagle schematic, and although it was tempting just to copy the rest of it, I did indeed keep tracing individual lines, and building up my own schematic – though it was nice to have something to compare with as I went.
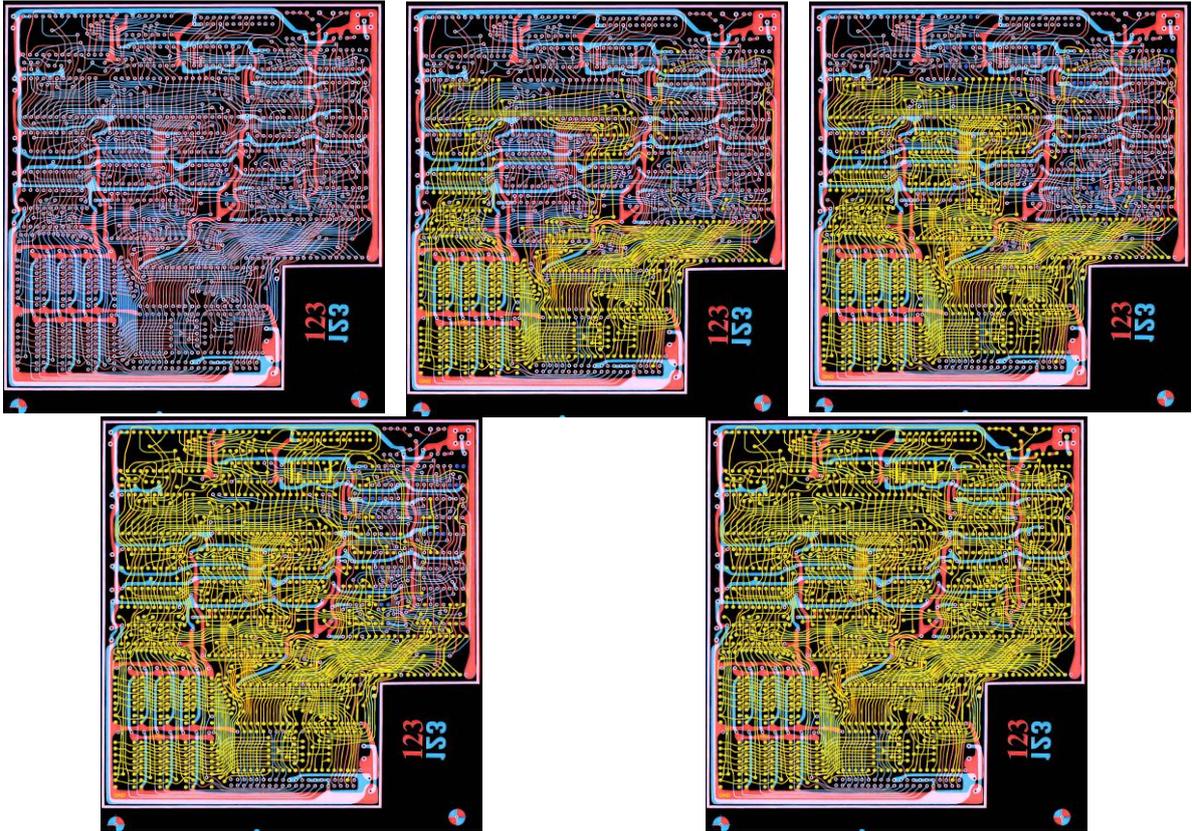
Gradually tracing the entire double-sided PCB whilst building the schematic.

So – I had a schematic…
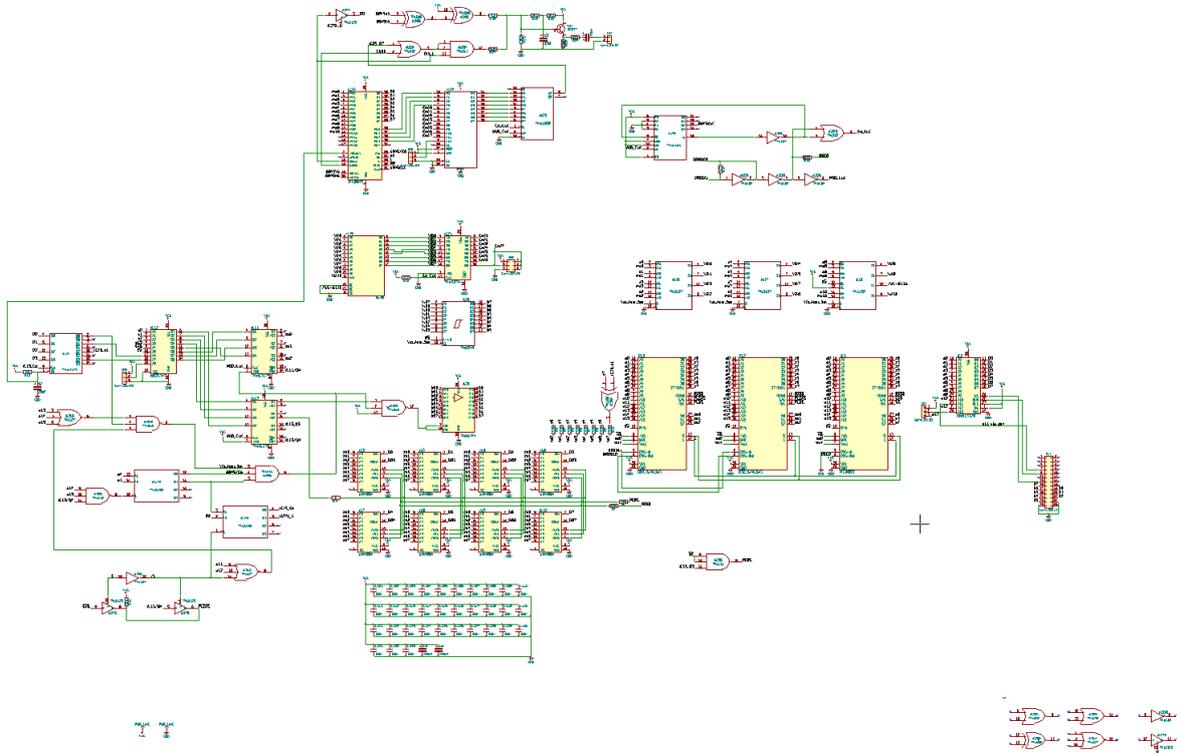
… now I needed to make the PCB.

Designing & Fabricating the PCB

I'll cut a long story short on this part – suffice to say that I've currently been through five versions of PCB design – with, as of January 2019, a sixth on its way from the fabrication plant.


From left to right:

- 'Alpha' 0.2 – this board caused me much frustration – in fact, I couldn't work out what was wrong. As ever, Phill proved to be the saviour, and found a much bigger error on my circuit than I'd expected – I'd somehow got the input and output of the DRAM data lines transposed. As you can just make out from those images (of a now somewhat disassembled board), the fix was to remove a chip, and directly connected the data lines across that. This then allowed the display part of the boards to work. This error may have come about either during the switch from Eagle to KiCad – or when I went from version 0.1 to 0.2 in KiCad, with some unjustified confidence speeding me on my way a little.
- Version 0.3 – whilst obviously fixing the DRAM issue from version 0.2, I also incorporated a suggested change from Phill – that of replacing the original video output connection with a two-pin socket, making it easier to plug a standard connector onto it robustly. Somehow I managed to mess this latter change up, and shorted out the signal and ground lines. It was salvageable with a cut to a track, and some abuse to a capacitor – but not very pretty.
- Version 1.0 – fixing the video output, I really thought I was close to releasing these – but I was still having issues. With some SAM chips they worked, and with others they didn't. After a couple of months of trial and error I decided that I was going to need to go back to the PCB 'drawing board' and undertook to create a new PCB layout using the exact trace routing of the originals – or as near as I could get.

With a reasonably clear printout of each side of the original PCB, I laid out every connection as per the original - and found one circuit error (the write enable from the Dragon board was connected directly to the SAM on the DragonPlus – and not into a different part of the circuit as it should be). Finding that error was a bonus, as I was really just recreating the exact original trace layout in order to eliminate any other issues that may have occurred as part of the auto-routing process.

I also had taken this opportunity to reduce the size of the DragonPlus 2019 boards a little, as Rob Owen had pointed out that my boards were somewhat bigger than the originals.
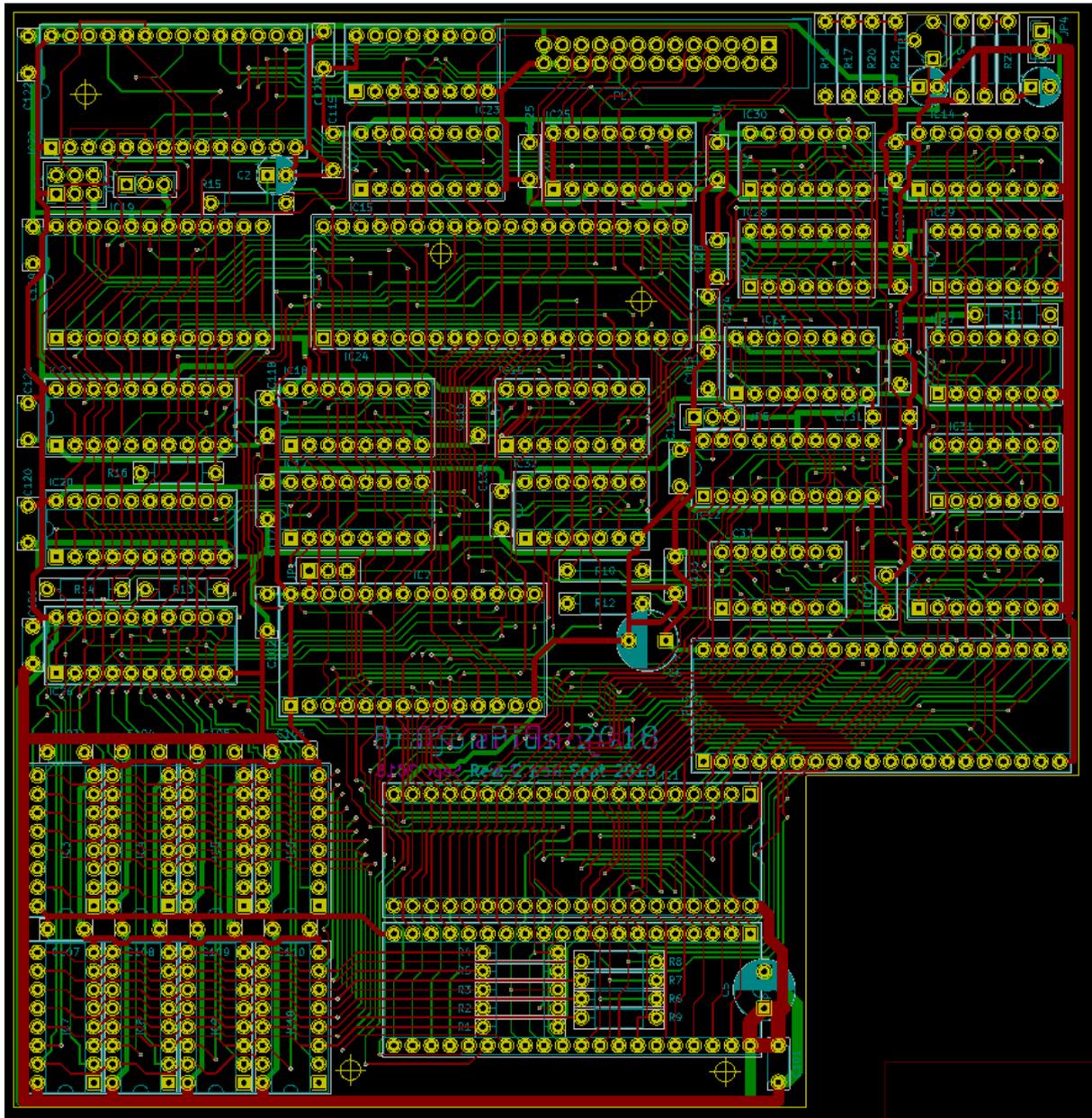
A version 2.1 board – with all traces and vias as close as possible to the original design.

So version 2.1 – all was good in DragonPlus-land? Unfortunately not. I'd neglected to do some design rule checks, and had a couple of tracks crossing across the ground plane – fixing with Kynar wire at least allowed me to move past those errors, but I kept coming up against other issues.

Other Issues Encountered Along the Way

When working with old devices such as the Dragon, and when attempting to faithfully recreate old add-ins for it, there is always going to be an element of unpredictability. I've certainly found plenty during this process – here are just a few.

Wear and Tear

Wear and tear – when prototyping, it is amazing just how many times these boards are plugged in – and pulled out. Eventually things just get worn, and they stop working – just one type of 'environmental' issue.

Old Components

Some of the components on this board are no longer produced. In fact, only the discrete logic chips are still produced, with the following chips causing their own issues:

- The N82S147 Bipolar PROM. Wow! This is an archaic device. No longer produced (unless you want E2V to fabricate in bulk for you), and rather unreliable to source personally. This chip is a predecessor to the original UV-erasable EPROMs. It is essentially a bipolar transistor device, which when manufactured contains many 'fuses' which are broken – or burnt out – during programming. This is a one-way process, so if a device is sold as being new, but has been used, it is useless. There is a way around this – but it is costly – around £10 per chip – money which adds directly onto the cost of this board.
- The character generation EPROM. Theoretically easy to source still, as they can be wiped and re-used. But still unreliable. I've bought devices which are sensitive to a finger being moved near them, causing all sorts of odd screen displays, as well as ones which are too slow, causing interference during the character generation process. The most amusing has been the purchase of modern, much faster devices which are essentially pin compatible, but which result in characters being sent to the screen one position early.
- Our beloved SAMs. These are getting on a bit. And they don't really like being pushed in and pulled out or circuits too much. In fact, they really don't like this with some of the turned pin IC sockets, which can grip too tight and damage pins. Hence I have moved to using standard IC sockets, and furthermore, moved to using ZIF sockets for the SAM. The same issue is true of the Dragon ROMs – but obviously these can be replaced by EPROMs, whereas the SAMs are becoming scarcer.
- The 6845 video chip – becoming rarer – so theoretically quite temperamental – but of all of the old chips in use, these have actually been the most robust.

Bad Disk Images

Bad disk images – OK – this one is a nightmare. When you are not convinced everything else is OK, you tend to place a lot of faith in the disk image. And when things don't work, you swap out components, remove and replace boards – trying to check components directly on the motherboard. If I've learnt one thing (and I haven't – I've learnt loads!), it is never to believe in a disk image implicitly. Ideally when

developing hardware, wherever possible, keep an unmodified machine as a baseline to validate that other peripherals and software are functioning as expected.

Back to the Making Again!

As I needed to order new boards without the crossed tracks, and as I was having hardware issues (the SAM socket was wearing incredibly quickly, and kept needing successive new IC sockets on the motherboard – not good for a 34 year old machine – I decided to modify the layout again for version 2.2, adding a 2x20 way port at the bottom of the board. I thought I'd be able to use this port for testing, leaving the main pin connectors unscathed for the end user. I was warned by Phill that it probably wouldn't work – but nothing else seemed to be working at this point either, so I took a gamble.

It didn't work – I'll get that out of the way quickly. It didn't even start and crash – heck, the Dragon wouldn't even boot. I have to say that at this point I got really, really fed up with the whole thing. I did try one other fix – which was to replace the SAM socket on the motherboard with 2 x 20-way header sockets – which were longer, and would mate with longer more solid pins on the DragonPlus. This approach did at least get me back to the sometimes working, but unreliable phase again. Christmas was coming – there was lots to sort out – and I pretty much gave up.

Practically all of December went by without me touching the boards – along with a week or so in January – but I finally decided to do some methodical experimentation again – on these new version 2.2 boards. I'd been trying various combinations of logic chip family – i.e. 74LS, 74HC and 74HCT – but just before Christmas I'd installed HCT chips throughout. I knew that the original boards seemed to contain a mixture of these chips and so I populated the board as faithfully as possible.

I plugged everything in – got the OS9 disk image ready – and BOOTed. The OS9 BOOT message appeared – followed almost immediately by around four random 'crash' characters on the right hand side of the screen. Taking a deep breath, and trying to remain positive, I decided to try running the board without the dynamic memory on it. And blow me, it worked – booting right into OS9, and only crashing when the command to format the virtual RAM was executed – obviously.

I started to plug RAM chips back in, one-by-one – and OS9 kept booting – until I plugged in the eighth chip. Swap that for another chip – still wouldn't boot. Removed the 8th chip – sometimes booted – removed 7th and 8th chip – mostly booted – removed 6th, 7th and 8th chips – always booted. It took a little while for the penny to drop – but as I knew that the RAM was all working well – I finally figured it had to be something to do with the power supply.

Cutting another long story short, it was all down to the ground rails on the board not being sufficiently wide enough to provide a reliable ground across the board. Actually, looking at the circuit board – the actual SAM chip's ground pin is about as far from the SAM socket's ground as it could be – via the tracks on the board. So I connected a jumper wire between the SAM chip ground and the ground rail right in the middle of the RAM chips – and lo and behold all was right again in DragonPlus-land.

After a fair bit of testing with OS9, Flex and Edit+, I then went back to version 2.1 of the board, corrected the crossed tracks, and manually reworked every ground and power track on the board, adding in some spare jumper holes in case additional power rail bracing was needed in the future. Version 2.11 is, as I write, winging it's way over from China.

The Future for DragonPlus 2019

There certainly seems to be a lot of interest in the DragonPlus. It's been a frustrating and taxing journey to get this far, but I have high hopes that this new batch of these boards will complement the single-digit number of the originals that are known to remain. Although the DragonPlus adds a separate video output to the Dragon, what wasn't properly understood until last year (well at least amongst the contemporary users of the remaining DragonPlus boards), was that if programmed carefully, the computer can actually be used as a dual screen system. Tony Jewell demonstrated this on his system at the UK Computer Museum in Cambridge. This does rather nicely open the possibility of high quality text accompanying the traditional 6847 graphics of the Dragon computer – maybe for somewhat more detail adventure games, for instance.

If nothing else, this has been a huge learning experience for me. I've somehow rekindled the spark of electronics that I once had in my youth - and hopefully, am giving something back to a fantastic group of Dragon enthusiasts.