SEPM New Assessment 2023: Project Management Case Study (based on real world events)

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Part 1

Chapter 1: A brief history

The first microprocessor was developed in 1971. As with many genre changing inventions it was developed by multiple parties in parallel – thus designs were available from Intel and Texas Instruments, amongst others (Betker et al, 1997). Even though the first CPU – the 4004 – was capable of little more than driving sophisticated pocket calculators. However, even in the early seventies, there were companies willing to try and utilise these chips in early microprocessor-based computers such as the Micral in France that was based on the Intel 8008 chip (Betker et al, 1997).

The personal computing/ home computer/ microcomputer (that is a computer based around a microprocessor) evolution in the USA had its roots in a hobbyist movement embodied in associations such as the Homebrew Computer Club (HCC) in California and the Amateur Computer Group in New Jersey (Betker et al, 1997). These were collectives of electronics hobbyists who met regularly to swap ideas, designs and even components. These organisations were served by magazines such as Popular Electronics, and it was this very magazine in its January 1975 edition that published a design (and kit) that would form the world's first commercially available microprocessor-based home computer – the Altair. This computer was based on the Intel 8080 – the successor of the 4004 and the 8008 but easier to design a system for, as well as being more powerful than the preceding chips. However, the Altair could hardly be called user-friendly. It contained no boot ROM (that is embedded instructions that told the CPU how to start the system) and so a user would have to input the start-up instructions in binary – using the set of switches provided on the front panel of the system.

Another system that owed its origins to the HCC was the Apple I, designed and built by Steve Wozniak and marketed and sold by Steve Jobs in April 1976 (Rawlinson, 2017). The Apple I was little more usable than the Altair – it was supplied as a bare circuit board without a power supply, keyboard, or display. It was also based on a different CPU – unlike the Altair which used the Intel 8080 the Apple was based around the MOS 6502. The main advantage the 6502 had over the Intel 8080 was cost – the 8080 retailed for around $150, the 6502 was available for $25 (Rawlinson, 2017). The Apple I retail price was $666.

The Apple][that was released in April 1977 was a very different machine. It was sold complete with integrated keyboard, power supply and a connector that allowed it to be used with a standard domestic TV and produce a colour display. It also had a number of expansion slots and shipped with BASIC in ROM as well. It found customers in business (due to the availability of Visicalc, the first spreadsheet), education and amongst the more well-heeled home users as well (the original retail price was nearly $1300)(Rawlinson, 2017). In business it had competitors in the form of a number of machines that used an Intel 8080 CPU (or a derivative), were fitted with a removable disc drive and ran an operating system produced by Digital Research known as CP/M. This OS gave access to similar 'killer' applications such as

WordStar and DBase II and for many was regarded as the early business standard. This period saw the release of several home/ personal computers including the Commodore Pet, the Atari 400 and 800 and the 2600 ‘games console’ – all based on 6502 family CPUs, and the Texas Instruments TRS-80, and various S-100 bus PCs (all based on Intel 8080 derived CPUs) from manufacturers such as IMSAI and Compupro.

IBM had been a relatively late starter in the field of digital computing, but by the sixties has established itself as the major business systems supplier thanks to its System 360 (and its later derivative the System 370). It had also made large inroads into the area of ‘departmental’ servers – these being smaller systems that could connect workers in a department – but would ultimately be connected to a larger ‘mainframe’ from the likes of IBM. It had ‘dipped its toes’ into the personal computing market in the mid-seventies with the IBM ‘portable’ computer (the 5100) but it was not microprocessor based, it did not run any of the standard operating systems or languages, and it started at $9000. Clearly, this was not designed to compete with the home/ personal computers mentioned above – however IBM senior management did not believe they could build a system in-house that could compete with these new machines on cost or agility – and yet they did not want to be excluded from this new market. After much deliberation they decided to set up a ‘skunk works’ department that was charged with designing a new PC – but based on off-the-shelf hardware and software and didn’t use in-house IBM systems or solutions. The result was the IBM PC (internal code 5150) which was initially offered with 16k of RAM, a keyboard, monitor but no floppy disk or hard drive. It retailed at just under $1600 (Carroll, 1993).

The UK had got off to a much shakier start in the emerging personal computer revolution. It didn’t have the equivalent of the Homebrew computer clubs, although it had an active community of electronics hobbyists, including a certain Clive Sinclair who started out reselling ‘refurbished’ components and eventually moved into kits such as pocket calculators. The UK market therefore had to base their designs on CPUs designed and sold by American manufacturers – which resulted in a certain amount of price gouging due to two factors: the first being the fact that disposable income was higher in the USA than the UK; and secondly that importers used a 1 to 1 ($ to £) translation for imported machines – even though the average conversion rate was over $2 to the £. The result was that imported components were expensive and imported machines more expensive still – some computers cost more than a new car in the UK.

The UK home micro revolution (as microcomputer-based personal computers were often known) started with an unsung hero – John Miller-Kirkpatrick – who was one of the electronics hobbyists mentioned above. Like Sinclair he started out selling kits and components, but a fortuitous meeting with the editor of a new electronics magazine – ETI – allowed him to move into publishing designs for microprocessors such as his System 68 based around an 8-bit Motorola CPU (Smith,2013). The designs were published starting in February 1977 and detailed how to build a complete system. However, the kit would still cost almost £250, which was a lot of money for a hobbyist in the late seventies. To cater for these users, Miller-Kirkpatrick designed a much more basic ‘evaluation’ kit known as the Scrumpi which was based on a much simpler processor the SC/MP, which sold for approximately £50 (Smith, 2013). The kit was only really suitable for learning low-level programming using a hex keypad, but that was the main objective of many of the early adopters.

Another similar entrepreneur, Chris Shelton, also developed and sold his own home micro which was known as the NASCOM/1. Unlike Miller-Kirkpatrick, Shelton was ‘commissioned’ to design the computer by a component importer John Marshall whose company imported many parts – including microprocessors – from the USA. Having seen the burgeoning 'homebrew' market in the US he was determined to create a similar environment in the UK (Smith, 2013). The NASCOM/1 was based around a z80 derivative (the Mostek MK3880) and was designed to use a standard television as its display, and an audio cassette recorder/ player for storage. Similarly, to Miller-Kirkpatrick (and the MITS Altair) the design for the NASCOM/1 was published in an electronics magazine – Wireless World – and was available as a kit or as a pre-built package. The initial articles appeared in Autumn 1977. The kit could be purchased for just under £200 without a PSU.

During this period, Clive Sinclair was still focused on the home electronics market, producing designs and kits for various projects including pocket calculators and a digital watch. The watch had several problems, and like several of the Sinclair projects didn't live up to the initial hype. The issues around the watch led to the UK Government advocating the involvement of the NEB – effectively nationalising Sinclair Radionics. One of the projects that the newly nationalised company was charged with was the development of a new microcomputer to compete with the Apple][. However, the aspirations of the NEB did not align with the low-cost designs that Sinclair preferred, and he was also unhappy with being under their management (Mathieson, 2016). During this period, one of his young engineers (Chris Curry) was tasked with setting up yet another 'Sinclair' spin-off company – this time it was called the Science of Cambridge (SoC). Curry was commissioned with finding a new, low-cost project for Sinclair to adopt. Curry was much more open to computing projects than Sinclair, and when he conceived a project for a microprocessor evaluation board (aided by another engineer, Ian Williamson), he hatched a plan to repurpose the unsold stock of Sinclair pocket calculators as octal programming handsets. Although the reuse idea didn't work out, the design eventually morphed into the MK14 in 1978 which was the first major project for the fledgling company, and Curry was bitten by the computer bug. However, Sinclair still had no real interest in producing a computer, so Curry left and formed CPU (Cambridge Processor Unit) with Hermann Hauser (Mathieson, 2016).

Ironically, the departure of Curry seemed to prod Sinclair into re-evaluating his position with respect to computers. He already knew from previous experience that computers were not the usual low-cost electronic devices he specialised in, and so he challenged his small development team to build him a personal computer for under £100. Incredibly enough (at least considering the price of all other systems out there) – the team did it. In February 1980 Sinclair Computers Ltd. released the ZX80 for £99.99 fully built, or £79.99 as a kit. It was a very basic machine, consisting of little more than a z80 clone CPU (a NEC µPD780C-1), a ROM and a number of TTL chips. It also had a number of flaws: it had a built-in membrane keyboard which was quite difficult to type on, the BASIC provided was integer only, and the screen would blank when the CPU had other processing to do. Nonetheless it was a proper PC and was less than a tenth of the price of even the most basic IBM PC. It was far and away the cheapest personal computer available in the UK or the USA – and it democratised the use of computers in the home user market (Adamson and Kennedy, 1986).

1981 saw the release of the ZX81 which was even cheaper – the kit was available for £49.99 and the fully built machine at £69.99. Despite been cheaper it also fixed a number of the problems of the previous model: it had a much more fully featured BASIC, it fixed the screen flickering/ blanking problem with some hardware modifications, and it replaced the TTL chips with a smaller number of ULAs. It also started the demand for accessories, peripherals, and expansion cards/ packs that would eventually create its own market(Adamson and Kennedy, 1986).

The original Acorn team consisted of Hauser, Curry and two Cambridge graduates (Steve Furber and Sophie Wilson). In 1979 they released their first computer – the Acorn System 1. It was based on a design by Wilson and used the 6502 processor (at the recommendation of Wilson) and was destined for use in research laboratories. In many ways it was very similar to the MK14 Curry had sold at Sinclair, but it was designed to be expanded into designs called System 2 to 5. Curry started to promote the idea of building a home computer at Acorn that would eventually be released as the Atom in 1980 at a cost of £120 as a kit, or £170 fully assembled. It enjoyed moderate success (McMordie, n.d.).

The British Broadcasting Corporation (BBC) had started to raise awareness of the evolving 'microelectronics revolution' as early as 1978 (Allen & Lowry, n.d.). Along with its education department and the British Government it launched an initiative known as the BBC Computer Literacy Project. The education department were used to producing books and programmes to support learning initiatives, as it had done for an adult literacy project some years earlier. It convinced the other stakeholders it needed a similar initiative to encourage and support the adoption of microcomputers in the UK. To make its programme successful it decided it needed a hardware system that demonstrated the benefits a computer could provide – and also used a programming language that was both easy to learn and powerful. It also worked with the national extension college to design and provide teaching materials and lesson plans that schools could use.

The project planned to launch its first batch of TV episodes and supporting materials in 1982, and so it started to look for a suitable hardware system towards the end of 1980.

An outline specification was sent to a number of companies, including Acorn, Sinclair and Newbury Electronics who were the new custodians of the NewBrain design. Both Sinclair (with the ZX82) and Acorn (with the Proton) had designs in progress. The NewBrain was still under development. Because of the involvement of the Government, it was assumed that the NewBrain was the preferred target system, however there were several technical issues with the computer, and the BBC decided it was too high a risk to gamble on for their programme. The second favourite was the Sinclair Spectrum (the ZX82) which was destined to be the most popular UK Micro of its generation, but Sinclair was unwilling to change the design of the Spectrum to meet the BBC's requirements. Acorn was very much a rank outsider, and according to some versions of the story didn't even find out about the BBC requirement until a week before the deadline. Nevertheless, as the story goes, the team worked pretty much 24 hours a day for that week, and just about managed to finish the test system with a few hours to spare (McMordie, n.d.).

The result was that Acorn won the BBC literacy contract and hundreds of schools purchased their computer – known as the BBC Micro - in large quantities which served to make Acorn a major player in the UK market, even though the computers were not cheap (the entry level model A was just under £300, and the model B was just under £400). This also (according to Chris Curry) stirred up a rivalry between Acorn and Sinclair (where Acorn resented Sinclair's success in the lower cost home/ games market and Sinclair resented Acorn's 'premium' position and hold over the education market). This wasn't helped by a government/ DTI initiative where schools could get a 50% discount off either a BBC or a Sinclair machine – because the BBC micros were so much more fully featured (and expensive) many schools saw buying the BBC as a better deal (Cane, 2016).

The final stakeholder in this short history is International Computers Ltd. or ICL. It was created in 1968 by the British Government as an attempt to create a British IT organisation big enough to take on the likes of IBM internationally. It was formed by a conglomeration of some of the most innovative and influential companies in IT such as Ferranti (who commercialised many of the University of Manchester's ground-breaking designs – including the first stored program machine and one of the first transistor-based computer systems); and EELM (who provided the first business system in the form of the LEO)(AIT, 2022). It provided departmental, workstation and mainframe computer systems for most of the UK public sector businesses, as well as for many European companies in conjunction with other European manufacturers such as Bull and Siemens. Just as with Acorn and Sinclair, there was a rivalry between IBM and ICL, and the new Managing Director, Robb Wilmot, was intent on making his mark and establishing his reputation within ICL. There had been a long rivalry both between ICL and IBM, and within ICL itself where conflicting factions were trying to control the direction of the company (Moralee, 1981). Wilmot's background was in electronics and his experience at Texas Instruments helped him drive ICL in a more open and connected way. He saw a future where PCs, departmental servers and mainframes all worked together, connected via various networking components and protocols. He was also interested in ensuring that IBM did not gain control of the emerging PC market, and that ICL should have a place at the table.

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Chapter 2: A hypothetical scenario

This is a hypothetical scenario, set in the early eighties and based on the brief history outlined above. It is **not** a true and correct history of the era, nor an accurate transcription of a real conversation. It is based on the information provided previously but may deviate from the actual historical documents – in other words it is provided as the basis of this assignment only and as such there is no 'right' or 'wrong' answer and the objective is not to guess (or research) what actually happened but to use your project management and analytical skills to create the best solution.

Participants: Colin Syn (Synful computing) and Will Burns (English Digital Computers)

2.1 Brief profiles

2.1.1 Colin Syn regards himself as a 'self-made man'. Born in the north of England, he started his working career at 16 in his father's shop, which sold radios and early televisions. He quickly became interested in the electronics hobbyist market in the UK and realised he could make some good income from this market. His first project was buying 'faulty' components in bulk for scrap prices, testing each component and selling the good ones as 'old-new' and tested stock. He then branched out into designing and selling kits, including radios, hi-fi and pocket calculator kits. He was never afraid of taking risks and has set up several companies and projects. He has no formal education beyond high school and so approaches every problem from first principles – which has had a surprisingly high success rate.

For every successful venture/ product, he has had two (or more) that failed. His motto for life: "always look after the pennies and the pounds will look after themselves." All his projects are designed to minimise cost first, so he can afford to abandon a failing product, undercut his competition and if successful make a healthy project.

2.1.2 Will Burns graduated from Oxford University with a first in PPE. Born into a wealthy middle-class family in the home counties, his ambition is to be the next great British PM after Winston Churchill. He is conservative in his beliefs and his politics and sees his role as the MD of EDC as a stepping-stone to his intended career in politics. His motto for life is: "manners maketh man." He regards himself as a shrewd and successful businessman with strong moral fibre and a good understanding of the electronics industry.

He is very careful not to be associated with anything that even appears to be illegal or underhand; he is also fastidious in his selection of projects and roles and at all costs avoids being associated with anything seen as a failure as he thinks it may jeopardise his future career aspirations.

2.2 Transcript

In November 1982 these two computing pioneers – Colin Syn and Will Burns (names have been changed to protect the guilty) - meet to discuss the possibility of creating a UK based personal computer that would compete with the relatively new IBM PC – especially in the UK.

Setting: An office somewhere in Central London. Behind a large Wooden desk sits Will Burns, managing director of English Digital Computers (EDC). There is a knock at the door.

Will Burns (WB): “Come in.”

The door opens and Colin Syn, managing director of Synful Computing, enters.

WB: “Colin, good morning. Thanks very much for coming over. Can I get you a tea or coffee?” He asks.

Colin Syn (CS): “Tea please, milk, no sugar”. He replies.

WB presses a button on his intercom and speaks to his assistant.

WB: “Hi Maggie, can I get a white tea, no sugar for Mr Syn and a black coffee for myself, thank you”.

CS: “Nice to see you again, Will. Why did you ask me to come over, anyway?” He asks.

WB: “I’d been reading about your potential new products in the trade press, and I thought I would get the truth straight from the horse’s mouth.”

CS: “I didn’t think you were interested in the home computer market?”

WB: “I’m not, but the trade press said you were working on a new business machine?”

CS: “Oh THAT interview – it’s one of the ideas I was looking at, yes.”

WB: “Well it’s something that I – and EDC – would be interested in as well.”

CS: “Oh really? Then maybe it WAS a good idea for us to meet up here”. He smiles.

WB:” So what do you think of the new IBM personal computer then?”

CS: “Not impressed. It’s stupidly expensive – my new Syn Rainbow that was just released is a far better computer for less than a tenth of the price. Also, my engineers tell me that the new 16-bit chip – the 8086 – is actually an interim CPU as the intended CPU from Intel was not ready in time. No one is going to develop software for an interim chip – and it is dead weight without software.”

WB: “yes, that’s a very good point. So, what CPU would you have used?”

CS: “Well my new Synputer – that’s the working name”, (Syn smiles), “will use a CPU from the Motorola 68k series.”

WB:” Ahh, the 68 thousand, very good. EDC have used the Motorola series in some of our Unix workstations and departmental servers.”

CS:” Yep – they also have forward compatibility – so any code written for them now will still work with subsequent chips.”

WB: “Yep – that is definitely a feature that EDC aim for – compatibility – sounds like your design could work for us. Tell me more.”

CS:” Well, its still on the drawing board – but the high-level principles are at least 512Kb of RAM, Motorola 68k series CPU, portable/ luggable form factor with built-in screen and storage drives.”

WB: “What about the storage? There seems to be a lot of options available at the moment. What do you think will be the new industry standard?”

CS: “I’m not really interested in the industry standard – we are working on a brand-new, solid-state, storage medium - high capacity, fast and low power.”

WB: “Really? That’s sounds fascinating – but I always think that having industry standard compatibility is very important – especially in business where people need to exchange data on a regular basis.”

CS: “Well, we could also add a standard drive – or make it an expansion option?”

WB: “Oh yes, so what about expansion options? How would that work?”

CS: “On the previous two Syn Computing machines we had an expansion option that allowed users to add both native and third-party expansion packs. There is no reason not to continue that approach with the new machine.”

The door opens and Burns assistant enters, carrying a tray.

Maggie: “Here you go sir, a black coffee and a white tea.”

WB: “Thanks very much, Maggie.” He smiles as his assistant leaves.

WB: “Now where were we?”

CS: “Expansion slots?”

WB: “Oh yes, I agree. An expandable machine is essential – and your approach seems excellent. I mean, technology changes so quickly nowadays and you don’t want to lock users into an obsolete system, do you?”

Burns takes a sip from his coffee.

WB: “So, what about the software? Any applications bundled? What about an OS and programming options?”

CS: “Well... I’ve already started conversations with one of our established suppliers – they have agreed to create a business suite that we can bundle with the system. It will have all the basic tools required – word processor, spreadsheet, database, graphics – a complete office suite. “

WB: “That sounds excellent – in our experience many users would need little more than the suite you just described.”

CS: “Indeed, and there are a number of choices for the OS, too. One of our team has already started work designing a multi-tasking, Unix-like OS in-house. Not only that but the same team is also working on a structured, modular superset of BASIC known as HyperBasic (HB). “

WB: “Hmm, doesn’t that seem like a lot of work for your team – creating the hardware design, the OS AND the programming language? Don’t you only have a small team? Aren’t you worried about having all your eggs in one basket, as it were? “

CS: “It’s true that we have used external consultants and contractors in the past, but they haven’t always delivered the quality or to the time scales we have expected – so we thought we’d try it in-house this time.”

WB: “Maybe we can put you in touch with some of the contractors and consultants we use?”

CS: “There is a Cambridge based consultancy called MCC that have said they can create an open version of Unix based on the BSD extensions with a MACH micro-kernel for the 68k processor family. I know some of my team have been chatting with those chaps down the pub.”

WB: “That sounds marvellous, the 3rd-party Unix that is. As I said industry compatibility is key. What about MS? Have you looked at their software? I know they have approached EDC on a number of occasions to provide a Basic and an OS for our systems, and I think they have a flavour of Unix available as well?”

CS: “MS? Their OS is allegedly just rehashed CP/M which is an old, limited system for 8-bit micros. And their BASIC is much too limited for what I need – my HB will replace TeleBasic (TB).”

WB: “TeleBasic? Isn’t that the language built into the education machines – the TelePCs? In my experience it’s better not to try and get clients to update or change their code – rather just give them a way to run their code unchanged on your systems. Have you looked into licensing TeleBasic and running the real code on your new machines?”

CS: “My engineers tell me that we can create a converter that will translate TB programs and allow them to run in HB without any manual intervention required. That is my preferred option because HB is much more powerful than TB and gives full access to the features of the machine. But I’ll look into the licensing option”, he adds as an afterthought.

WB: “So apart from the expansion slot, what other ports are you fitting? Businesses are increasingly looking for standard access to centronics printers, serial ports for networking and communications, a keyboard connector and even SCSI are all becoming increasingly important.”

CS: “Well, I hadn’t considered ALL those connectors, but certainly there would be serial ports and a keyboard connector – and of course a connection for an external display.”

WB: “The external keyboard is important in a business machine – many European countries have different keyboard layouts and it’s much easier to just change an external keyboard than it is to have to modify an integrated keyboard. Also, our future systems are destined to be integrated as part of a networked product line – so some form of networking would be essential.”

CS: “Surely the serial ports would be enough for that as standard? My engineers tell me they can be used to accommodate standards like RS 422 and RS 485, and they can always be used for modem connections as well?”

WB: “Indeed, multiple serial ports would be ideal – one could be dedicated for networking and the other used for additional connections. What about the gaming connection? Are you intending this as a machine for your existing users to aspire and eventually upgrade to?”

CS: “Oh yes, we have an application in the pipeline that will emulate our older machines – the new machine will be so much faster that an emulator will easily be able to run ALL the old games at the same speed as on the existing machines, and even let users run a word processor at the same time! Just need to add a joystick port and we're sorted." He laughs.

WS: "Excellent – yes, emulators for backward compatibility are something we use too. And being able to run them alongside business applications – first rate!"

CS: "So that's about as far as we have got at the moment. Of course, for it to be portable we'd have to keep it light, we are looking at a maximum of 2 kgs that would have to include the computer, batteries, screen and any peripherals – that might be a challenge. I'd expect at least 2 hours running on battery for it to be worthwhile. At least we have a 4" low power screen I've designed in house already", he muses.

WB: "Well that sounds excellent. In fact, we'd like to get involved in the project – so how best can we help? Engineering, procurement, design?"

CS: "Our current major challenge is capital, as it always is for small companies – so if there is any help you can provide in that area?"

WB: "Yes indeed. I'd need to run it past the board but what about if we buy a number of machines up front – on spec as it were? What is your current cost price target?"

CS: "We're aiming for a cost price target of £200 per machine."

WB: "£200? That seems awfully cheap. Tell you what, lets work on a cost price of £250 – and we will buy 2000 machines at cost, based on the specifications we've agreed today. That would be an upfront purchase of £500,000. Would that help you with your capital challenges?"

CS: "That'll do for now." Replied the canny northerner.

A few days later the deal is confirmed, and Syn Computing receive a purchase order for £500k from EDC. The design and production of the Synputer is fully funded by that purchase alone.

2.3 Additional information

You have also been supplied with two bills of materials (BOMs): one that details (possible) hardware components (appendix 1) and one that details (possible) software components (appendix 2). These BOMs can be used to create costed estimates and to produce project plans and forecasts. There is also a list of rates of various resources below that you will require to build a system to the specification you have extracted from the discussion reproduced above.

Chapter 3: Miscellaneous information

3.1 a complete system

A complete system consists of: 1 or more ROMs, 4 'glue chips' (G1 – G4), A CPU, 4 RAM chips, interface (I/O) chips for serial, keyboard, video output, a keyboard (built-in or external), screen (for portable/ luggable), storage drive(s) and a case (desktop or portable) as per your design.

Software: depending on the OS some will be installed in a ROM, but all OSes require additional disks (or cartridges) with utilities and so on.

The machine also comes bundled with EZ-SUITE business applications; note these only run under HB/OS but the licensing deal requires that every machine pays a £25 charge for the applications, regardless of OS.

3.1.1 ROM (Read-only memory)

ROM can be 8KB, 16KB, or 32KB. The board has space for 2 ROM chips – and the minimum you need is a single 8KB ROM that contains the boot loader and the hardware configuration app.

The maximum ROM size is therefore 64KB. All ROM chips are the same physical size and can be fitted in either location (or socket).

ROMs need to be written {or 'blown') in one pass, and once written cannot be reused – they can only be replaced. The one pass write means that content/ code from multiple producers cannot be mixed on a single ROM – which is not a good idea anyway.

Code from different manufacturers is unlikely to work together – even if located in different ROMs. For example, the HyperBasic interpreter will not run under the MccOS.

MS will create and supply their own ROMs – they will supply 1 x 16KB ROM with the boot loader, DOS system files and BIOS, and another 16KB ROM with 68KBASIC.

3.1.2 Glue Logic/ ULA/PLA

Early computers (and the ZX80 in particular) used many simple TTL logic chips to create routes or functions between the main chips (such as RAM and the CPU) on circuit boards. This increased the cost (and failure rates) of early computers due to increased component costs, increased soldering times (and costs) and layout complexity. As computers became more common, these TTL networks were replaced by LSI (large-scale integrated) devices known as ULAs (Uncommitted Logic Arrays) or PLAs (Programmable Logic Arrays). In the early eighties these started to appear in most systems – for example, the ZX81 reduced the component count from its predecessor by a fifth (and its cost by almost 50%) via the use of ULAs and the BBC Micro was also based on large ULAs. In fact, the main reason for the production delays of the Acorn Electron (the BBC Micro's 'baby brother') was attributed to production problems with one of the largest ULAs ever produced.

The Synputer uses 4 ULAs – one that connects the I/O devices to the CPU, one that 'manages' the RAM, one that 'manages' the display and a system ULA that connects all the other ULAs together. Due to the nature of these chips, if the pin layout or function of any of the 'managed' chips changes, the ULA will need to be changed. Also, the one that 'manages' the RAM may also need to change if the RAM chips are changed because the ULA contains the address decoding circuit.

The IOP ULA has been designed so that it can support ALL the IOP (and INTSND) chip options currently offered on the HWBOM. Each IO and INTSND chip on the BOM can be identified automatically by the ULA, and it routes signals/ data as appropriate. This does NOT mean however, that software at the OS and/or application level will work unchanged.

There are two chips, SC100 and SC150, that are ULAs designed by Synful Computing internally. These have been used in other products and can be used in the Synputer as well. The SC100 replaces the UART and multiplexes two serial connections over 1 physical port; it can (alternatively) be used to provide an RS422 or RS485 physical layer network connection. All these options need custom cables to access them. Note that the network connections are only at the physical layer; Synful Computing currently do not provide a software stack for a network – this would have to be provided by a third party.

Likewise, the SC150 chip can be used to replace the J6100 joystick interface chip. It provides 2 channels of digital/ serial data over a single joystick port. These channels can be used for two (digital) joysticks, two mice, or two external keyboards (or any combination of the above). The functionality is again decided by the custom cables used, and the chip is intelligent enough to detect what is connected (assuming the correct interface cable has been utilised). Again, country and character set support are a software function that needs to be provided in ROM or on disk (depending on the OS selected).

The DISP ULA contains the logic required to provide a basic 512 by 256 display, with 32 colours. It connects directly to the video output port, but it needs an appropriate cable/ adapter/ modulator to connect to a digital monitor or TV. These are not supplied with the machine but can be purchased from Synful Computing. To get a higher resolution display, or more colours, the DISP ULA must be modified, and an additional chip (the GDISP) might need to be added to the board as well (depending on the requirement).

The storage drives (floppy or cartridge) are connected to INTSND ports, one port for each drive. The logic is slightly different for each type of drive, and thus the ULA needs to be modified depending on the type of drive fitted. In addition, software libraries and filesystems are also specific to each type of device. As each INTSND chip offers different audio facilities, the software libraries and device drivers also need to be changed dependent on the chip used.

3.1.3 Components: sockets vs. soldered

All components can either be soldered directly to the board, or ICs (integrated Circuits ‘chips’) can be mounted in sockets. Direct soldering has the advantage of lower cost and quicker (and cheaper) production. The advantage of sockets is that pin-compatible components (such as ROMs) can be replaced by the users as opposed to having to buy a new board or returning the original machine to the manufacturer for upgrades.

3.1.4 Weight

The batteries weigh 1.9 Kg.

The portable case weighs 0.8 Kg.

The board, components, drives and and screen weigh 0.65Kg in total.

3.1.5 Power consumption

A complete system with a 68008 CPU, 4 glue chips, 1 x 32KB ROM, 4 x 32Kb RAM chips, 2 std. (3.5”) floppy drives accessed intermittently, ran for 20 minutes before shutting down on fully charged batteries.

A complete system with a 68008 CPU, 4 glue chips, 1 x 32KB ROM, 4 x 32Kb RAM chips, 2 Syn cartridge drives accessed continuously, ran for 15 minutes before shutting down on fully charged batteries.

3.1.6 Boot priorities

The default setup is that the boot loader will first try and access drive/ cartridge A to locate a boot sector, then drive/ cartridge B, if neither drive has a boot sector it will default back to loading BASIC from ROM.

If there is no ROM BASIC, the system will hang until rebooted.

This behaviour can be changed using the HWCFG app also located in ROM (assuming that an appropriate ROM is provided).

There is no provision on the motherboard for a real-time clock or battery backed non-volatile RAM (NV-RAM).

3.1.7 Run-time behaviour

The default in-house OS and BASIC (HB/OS) will try and write error and warning messages to a log file created and stored on media located in drive/ cartridge B. If there is no available media in that drive, or if the media is full and/or write protected the HB/OS will crash. This behaviour can be changed using the HWCFG app or by editing the CONFIG.HB file on the boot disk. Logs can be written to a RAM disk, if available and configured by the HWCFG app.

Similar functionality is required for MccOS where the kernel and associated applications will attempt to write messages to a log file on drive/ cartridge B. As above, the system will crash without accessible media. Logs can be written to a RAM disk, if available and configured (via KNLCFG).

68kDOS does not log messages as default.

3.1.8 Memory

RAM	OS	Functionality	Multi-tasking	RAM Disk
128KB	HB/OS	Single BASIC session **or** application	N	N
128KB	MccOS	Shell and simple app	Limited	N
128KB	68KDOS	Shell **or** single app	Does not support multi-tasking	N
512KB	HB/OS	Multiple BASIC sessions **and/or** apps	Y	N
512KB	MccOS	Multiple shell sessions/ apps	Y	N
512KB	68KDOS	Shell **or** single app	Does not support multi-tasking	N
1MB	HB/OS	Multiple BASIC sessions **and/or** apps	Y	Up to 500KB
1MB	MccOS	Multiple shell sessions/ apps	Y	Up to 250KB
1MB	68KDOS	Shell **or** single app	Does not support multi-tasking	N

3.1.9 Resources

Roles	Internal Cost (Day)	Agency Cost (Day)	Tasks/ Skills
Hardware Architect	£250 (1)	£400	Design, layout, Fault finding
Software Architect	£300 (1)	£450	Design, Coding, Fault finding
HW Engineer	£175 (2)	£275	Build, test, troubleshoot
SW Engineer	£195 (2)	£295	Code, test, troubleshoot
Project Manager	£275 (1)	£450	Plan, manage, reporting, costing
Project Analyst	£175 (0)	£250	Update, replan, resourcing, costs

Notes: Numbers in brackets are the number of resources available within Synful Computing and assigned to the project. Assume that the agency has unlimited skilled resources but allow planning time for on-the job training.

3.1.10 BOM notes/ key

Please see BOM sheets for details. Miscellaneous factors are provided below:

Case build capacity: Maximum of 20 per day.

Board production capacity: Maximum of 25 boards a day.

Pin compatible: No changes required to **board** if component changed.

Code compatible: No changes required to **code** if component changed.

Chapter 4: Operating systems

4.1 HB/OS

The (HyperBasic/ OS) is the default in-house OS and BASIC. The OS system files do not come with any CLI/ Shell – all access to the OS is via HB – therefore it is important that if the default OS ROM is provided, then the HB ROM is provided as well. The default operation is that if there is no boot sector on any media inserted into the storage drives at run-time then the system will default to running the OS/BASIC in ROM and it will initiate a HB session. As mentioned above, the OS ROM does not provide a shell, so the default CLI is “>” which is the HB prompt. HB can be run in interactive mode, so that any HB command entered at the prompt is executed immediately – thus the LOAD command will retrieve a file from disk into memory, PRINT will attempt to display it on-screen (or send it to a printer if a channel is configured) and SAVE will attempt to save whatever is in memory to a file on disk. Note printing a binary file to screen may cause the system to crash. AUTO will start the autonumbering system to assist in writing a BASIC program. The only editor available is a simple line editor. More sophisticated shells, editors and tools can be created as HB programs themselves and simply loaded into and executed by the interpreter. Extensions to HB can also be loaded from disk. Note that on an 128KB machine an area of RAM is reserved as a scratch pad (for program variables and so on) and approximately only 90KB is available for applications – this is further reduced if HB extensions are loaded as well. For example, this means that HBConv, the utility used to convert TeleBasic apps to HB apps cannot be loaded into memory fully on a 128KB machine – this means that a lot of swapping to disk and loading of overlays occurs with this application and progress may seem very slow.

Note that many bundled files/applications come as **tokenised** HB – that is they can be run but if you try and LIST the contents you will just get garbage on the screen.

The bundled EZ-Office suite (consisting of EZ-Writer, EZ-Sheet, EZ-DB and EZ-Graph) is designed to run as an HB/OS application – it does not need (and indeed will not run) under any other operating system. To be able to multitask the EZ-Office suite applications the computer will need more than 128KB RAM.

As well as HBConv, Synful Computing have announced that they will be releasing an emulator so that games written for older Synful machines (including the latest Rainbow) can be played on the Synputer.

4.2 MccOS

MccOS is a true Unix-like system, although architecturally it is quite different as the kernel is based on MACH and many Unix kernel functions are carried out by user-space servers managed and scheduled by the kernel. Nonetheless, from a user perspective it appears to be a standard Unix (2.8BSD) system. The default shell is ash and all the standard tools such as: more, tar, bzip, Vi, etc. are available. Additional Unix tools can easily be ported using the PCC compiler. It comes as a set of 10 disks or 20 cartridges, but the boot disk has been configured so that a limited but usable set of tools are available – nevertheless this boot disk should **not** be regarded as a complete BSD distribution in any sense. For example, all the documentation (man files) are zipped up over two disks and in reality, a hard disk is required to set up a 'normal' distribution. 128KB with two storage devices is the bare minimum machine specification required to run this (modified) system, and even then, there are restrictions in place: multitasking is very limited and you will not be able to run more than 2 shell sessions concurrently – and you may find that some applications will require a lot of swapping to disk – which will be painfully slow on a floppy or cartridge system. You will **not** be able to compile or port any new applications on such a low specification system. It is recommended that you have access to a full Unix system with a cross compiler, or a 68k based workstation in order to port applications to the Synputer.

This system is a purely CLI-based system, no graphical applications are included.

There are two programming languages currently available: C via Vi and the PCC (Portable C Compiler), and the UCSD-Pascal environment. These are available (for purchase) as additional disks.

Note that HB applications will not run under MccOS – but you can reboot the system back to the in-house (HB/OS) system and then run HB applications as normal (assuming the HB/OS ROMs are installed).

Finally, the standard HB/OS ROM will boot the specially configured MccOS boot disk, but if you want to set up a full BSD system, or you want the ability to define new devices, add a hard disk, update the kernel and other specialist Unix-related tasks you will need a modified boot ROM (known as the McROM) where the standard bootloader and HWCFG app have been supplemented by a BSD compatible KNLCFG application. This is a special-order item and will need to be built/ configured as a special order from the factory.

4.3 68KDOS

68KDOS is an independent port of the DOS system (based on CP/M68K) to the Synputer. It includes all the standard (operating system) tools, and it has the standard BIOS files and 68KBASIC in ROM. As per

SOP (and explained previously) the system will look for a boot floppy in drive/ cartridge A in order to boot into DOS, and if there is no boot sector on the media in that drive, it will check drive/ cartridge B before defaulting to running 68KBASIC from ROM.

Note that the ROMs provided as part of the MS package are from MS directly and therefore do not include any code/ utilities from Synful computing – in particular the HWCFG application is **not** available.

Note that although disks from an IBM PC can be read (assuming they are the newly emerging 3.5” format) and the disk format is the same as the IBM PC, you can only read text/data files – IBM PC applications will not run as the Synputer CPU is completely different to that in the IBM PC.

MS have announced plans to port their own applications to the Synputer – but so far, no other applications have been ported. Source code for IBM PC/ DOS applications is not usually available so Synful Computing (or users) will **not** be able to port other applications.

Part 2

Assume that the following changes occur approx. 12 months after the plans and estimates for part 1 (above) were created. (NOTE TO LEARNING TECHNOLOGY: Is it possible to delay the release of this section until after week 6 of the module?)

Chapter 5: Project amendments

5.1 Challenges

- Despite their best efforts, the engineering dept. was not able to produce a viable solid state storage device; Syn has decided to use his own (internal) cartridge system (previously designed for the Rainbow) as original demand was low, and the company have considerable stock to clear. No-one else (in the industry) uses this type of drive.
- After seeing the results of the experiments, Syn has decided to abandon the portable/ luggable form factor and build a desktop machine instead – this will include an (internal) keyboard built into the case.
- EM interference from the floppy or cartridge drives motors cause random resets of the system.
- Testing of the HBConv app reveals that it can only convert about 50% of existing TB programs – and even then, about 20% of the converted code needs manual tweaks to get it to work properly.
- The Game Emulator app is 64KB in size – it needs its own disk/cartridge to hold the emulator app, the computer images(s) and any bundled games; it needs the HB extensions in ROM/ RAM to run. It also needs at least 128KB of RAM in the Synputer.
- Marketing have already placed advertisements in all the major computer, electronics and business computing magazines advertising the Synputer as available for sale from 1 December, 1983 at a price of £399.99.
- Marketing have informed Syn that existing users need an upgrade path, or they will buy a machine from competitor – users are looking for a system with high resolution graphics (512 colours, 1024 x 768 resolution, 3 channel sound and ability to play samples), with ports for a mouse & two joysticks; it should also run games from older machines. This should be available at the same price as the current machine – it may be possible to add a small premium (<10%) to accommodate the change in specifications.
- A market research survey has revealed that the majority of those polled believe a CLI based machine is 'old fashioned' and 'old tech' - most users (business and home) expect a machine with a GUI that can be driven from the keyboard and/or mouse.

5.2 Default system specification

Despite (or maybe because of) your advice, Colin Syn has decided that the shipping model will have the following specification, and he has sent a evaluation system to EDC.

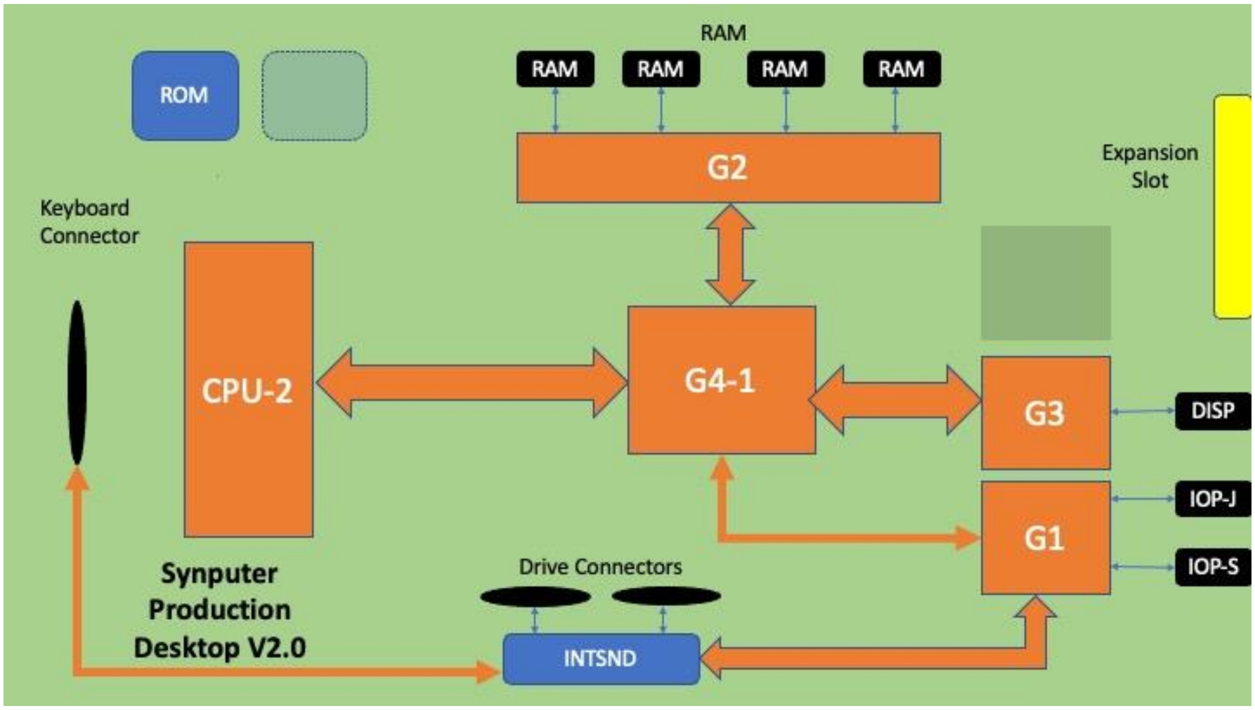

Figure 1: The layout of the Production Synputer Board

The shipping specification is:

- A complete system will be a desktop unit with a 68008 CPU, 4 glue chips, 1 x 32KB ROM, 4 x 32Kb RAM chips, (all soldered to the board), 2 Syn cartridge drives, 1 serial port, 1 joystick port, a desktop case with internal/ integrated keyboard. It has a custom composite video port, but no cables or modulator are supplied to connect it to a monitor or TV. The standard display is 512 by 256 display, with 32 colours. It also has basic monophonic sound, connected internally directly to a case-mounted speaker – effectively it just produces beeps. All components are soldered on-board, with no socketed components. It also includes 4 cartridges (2 BASIC and 2 for EZ-SUITE) and a printed manual that covers basic operation, an introduction to Hyperbasic and a full list of keywords.
- Within a few days they receive an **official complaint from EDC** – expressing their extreme disappointment at the specification of the system they received and threatening to sue for £1 Million for breach of contract unless the specification of the system is upgraded so the majority (> 80%) of their requirements are met. For the avoidance of doubt, they restate their requirements in order of importance:
    - Industry standard operating system
    - External keyboard/ connector
    - At least 512KB of RAM
    - At least 1 industry standard removable drive
    - SCSI expansion capability
    - At least a 68000 CPU – preferably upgradable
    - Minimum of 2 serial ports that support RS 422/ 485 standard
    - Board is ready to support a GUI system and mouse if required by the user

- EDC demands an official response that details how the above requirements will be addressed and a plan for how quickly the modified systems can be manufactured.

5.3 OS/ GUI developments

- BSD have released an updated version of their OS; it comes with the option of an X-Windows implementation (a GUI for Unix systems) – but only for a HiRes display (and with the UWM window manager see link: https://en.wikipedia.org/wiki/Ultrix_Window_Manager). MCC have quoted a development window of 8 weeks design, 16 weeks coding work to port it to MccOS. An external SCSI hard drive is HIGHLY recommended, along with a minimum RAM of 512KB.
- MCC have also announced a licensing deal with TelePC to supply TeleBASIC (TB) for MccOS. This is available at a cost of £25 per machine for volumes of 1000 machines or more.
- The internal team can design a pointer environment (PTR/E) that provides a WIMP solution; it will be written in HyperBasic and will need as many extensions in ROM as possible. Again, due to library and extension requirements, a 512KB RAM machine and a hard drive is strongly recommended. The team have quoted an 8-week design phase, and then 16-week coding phase. An example can be found at this link: http://www.dilwyn.me.uk/gen/launchpad/launchpad.html)
- MS claim they can port the GEM graphical environment – they are quoting a 12-week design phase, with 26 weeks coding effort following the design. The new system requires at least version 2 of 68KDOS – this is available as a new 32KB ROM which includes 68KBASIC, along with a 2nd 32KB ROM that holds the core GEM files and libraries. They are also promising a free upgrade to their own, internally-created GUI environment when it is available. Although they also recommend a 512KB RAM machine, and it will require new ROMs, they claim it will work with existing storage devices. An example link is at: https://en.wikipedia.org/wiki/GEM_%28desktop_environment%29
- A small hobbyist supplier that has previously worked closely with Synful has produced an extension board called the Pro Expansion board for the Synputer. It has sockets for a 68000 (or better) CPU, plus sockets for a new ULA, 4 RAM chips (up to 1MB chip per socket) and a socket for a chip to drive/ manage the provided 25 port Centronics-style connector that can be used with an adapter cable for SCSI or parallel printer connections. The board is supplied **without** any ULA, RAM, CPU or I/O chips but it is highly flexible. The supplier offers it at a price of £15 to Synful Computing if they buy it in quantities of 1000 or more.

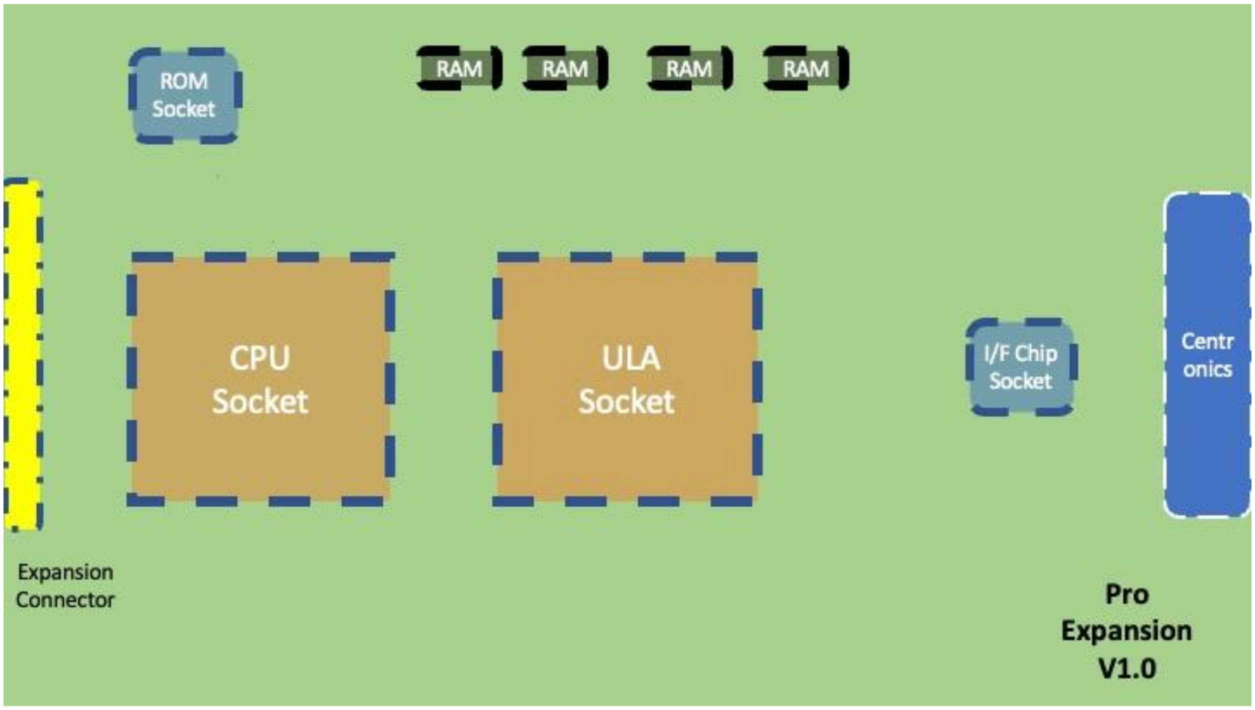

Figure 2: The Pro Expansion Card

Chapter 6: Another project

6.1 The XV saga

The XV chip was developed by an American research company as part of their research into 2D and 3D computer graphics. Its first iteration was on a dev/ eval board that was sold for $500 per board, designed to introduce/ entice developers to use XV technology to create advanced 3D apps such as flight simulators, and suchlike. The sales brochure claimed the board provided a frame buffer, built-in 1MB VRAM and advanced features such as shading, accelerated geometric functions, BIT BLOCK translation (BLIT), and so on via dedicated instructions/ programming language. The boards were purchased by developers for Unix/ X-Windows Workstations and for professional/ industrial flight simulators. The ones used for W/X-Windows applications were fine (as they essentially just used the frame buffer and 'automatic' 2D acceleration features) – but those that explored the 3D programming/ API functions found several faults – amongst them were the fact that the board ran hot when executing the dedicated 3D commands, and even worse certain commands caused the chip to crash due to the fact they either hadn't been implemented or that they called unimplemented features – in these cases professional developers (correctly) returned the chips as faulty.

Colin Syn – realizing he might need to produce a Unix/ X-Windows workstation as part of his EDC deal – was looking for a chip to use. He came across the XVX but was told by his supplier that they were faulty. This reminded him of his early days in electronics, when he used to purchase faulty components, test them and sell on the known good devices. He purchased the entire stock of 'returned as faulty' chips (numbering 1000) for $25 per chip, surmising (correctly) the fault was with the more advanced functions which hadn't been debugged. The manufacturer insisted that these chips could NOT be sold as XVX chips (concerned about damage to the fledging company's reputation) and Syn agreed to sell them as Syn manufactured ULAs known as GDISP chips.

However, demand for X-Windows workstations from EDC was light – only 100 were ordered/shipped, so 900 chips were still left in stock.

6.2 Ten years later

Moving to the nineties, Synful computing were approached by AMI to design a hand-held game console. Colin Syn mandated to his engineering department that the design should use the XVX chips still in stock as they seemed to meet the client requirements. Unfortunately, the code written by AMI – especially for the hyper glider game – made use of the advanced functions of the chip. As previously, the use of certain instructions caused the chip to crash – and unfortunately the design linked the reset lines of the chips together, so when the XVX chip crashed, the console was reset. AMI investigated, and after checking for electronic interference, poor code design by Synful, and poor design of the GX chip, found that the fault was in the XVX chip and NOT in the Syn design, and insisted that XV fix it. Due to the fact that AMI were a big games producer and a big (potential) consumer of XV technology, XV succumbed to pressure and agreed to fix the issue. AMI confirmed their code ran fine on the latest NV2 chip (a 250Mhz part with 0.5MB V-Ram on a PCI card) – and they recommended that XV implement the XV2 core in the XVX chip. After many arguments, XV agreed to repackage the XV2 core with 1MB of VRAM locked to 100Mhz into a pin-compatible XVX chip – but they insisted it was renamed to XVZ and only used for this specific application. Synful Computing were paid for the re-engineering and for the redesign of the GX chip, but unfortunately, they were still left with almost 900 XVX chips.

6.3 XVX Chip evolution

Graphics Chip/ Generation	Form Factor	Cost	Specification
XVX – 1982, 2D/3D testing	Eval Board	$500	4k cols, 1024x768, 1MB VRAM, 100Mhz
XV1 – 1989 – 2D accelerator	Individual Chip	$250	4k cols, 1024x768, 1MB VRAM, 100Mhz
XV2 – 1995 – 2D/3D acc.	PCI/ AGP Card	$299	64k col, 1280x1024, 0.5MB, 250Mhz.
XVZ – 1995 (custom)	Individual Chip	$100	64k col, 1280x1024, 1MB VRAM, 100Mhz.

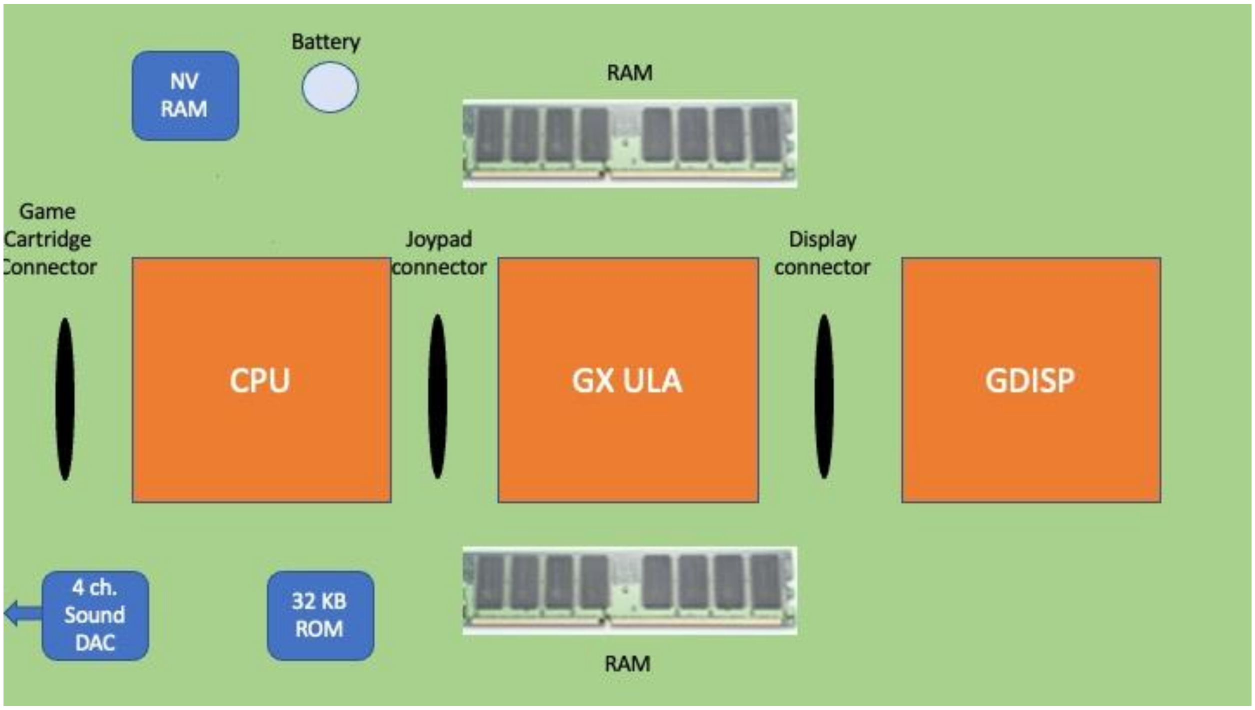

Figure 3: The Games Console Board