Has the fun gone out of engineering?

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The Author has seen widescale changes in the role of the studio engineer during his thirty and more years in broadcasting. In this article, he describes many of these changes and gives his personal views on the problems which are being caused by the convergence of computing and broadcasting technologies in the television studio.

1. Introduction

I am often asked to give talks to school children on Engineering – as part of a scheme organized by the UK Council of Engineering Institutions – and one of the points that I discuss with the children is that of the definition of an engineer. I like to think that one of the derivations of the word is *ingenious* – somebody who displays ingenuity. Being an engineer in the world of modern television broadcasting certainly requires a great deal of ingenuity.

Studio engineers were traditionally trained to investigate and repair faults. Initially, broadcast equipment was so unreliable that, for example, the BBC had to employ engineers as operators in order to keep the equipment on-air. These engineers "drove" their machines to gain the best performance. The thought of leaving the equipment to look after itself in "auto mode" was an anathema to them. There are still vision controllers or colour balancers today who claim to be able to colour match better than the computer lined-up cameras in a multi-camera studio. However, the studio equipment has moved on and engineers must move on too. The ubiquitous microprocessor has taken over and most of our equipment now contains at least one if not several "chips". Yet there are those who still hanker after the old days.

One of the most popular stands at last year's IBC in Amsterdam was that of the UK's National Museum of Photography, Film and Television who displayed a selection of vintage cameras from the 1950s and 60s. Nostalgia ruled: rows of engineers gazed admiringly at the old equipment, remembering their days working at the Wood Green Empire or at Lime Grove Studios (both in London), doubtless wearing sports jackets complete with leather elbow patches, and sighing "I remember the night when . . . ".

Those days weren't really good old days: the initial reason for having four cameras in a studio was to make sure that you still had two giving out pictures by the end of the transmission! Cameramen used to fight over who was going to be able to use the one zoom lens allocated to the studio.

People in other walks of life don't all pine after the old days. If it's not too politically incorrect to say so, how many housewives pine for the good old days of the washboard and the washing dolly in preference to an automatic washing machine? We

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engineers must move on with the times as well. After all, there are enough problems with the television equipment of today without wasting time pining for the problems of yesterday's equipment.

In this article I hope to compare some of these problems and show how we engineers must rise to the challenges of today's equipment. The fun hasn't really gone out of engineering!

2. Maintenance in the 1960s and 70s

Initially, the equipment of this era was made of plug-in printed circuit boards (PCBs) or modules and, when they failed, the engineers could use the methods in which they had been trained to analyse the fault down to board level and then, hopefully, to trace the fault down to component level. The faulty component could be replaced using a soldering iron. Common faults were known, if not by you, then perhaps a colleague would probably have seen the fault before. One of the most common faults with early equipment were problems with the edge connectors – those printed strips of copper, flashed with gold – which carried the signals to the rest of the machine or to the next PCB. Unfortunately, these problems are still seen on modern equipment.

Indeed, at the BBC Engineering Training School at Wood Norton (central England) – a place that is remembered with fondness by many UK broadcast engineers – one method used to simulate faults on equipment, for fault-finding exercises, was to put *Sellotape* (Scotch tape) on the edge connectors in several of the individual signal paths. You were supposed to deduce the fault by logically working out which part of the circuit wasn't working correctly and by finding out which signal was missing. The more devious of us found that the simplest way to find the fault was to run your fingernail along the edge connector to feel the *Sellotape*. Of course you would then spend just as long making up fictitious tests that you had carried out in order to find the fault! As mentioned earlier, edge-connector problems still remain with us today, even though printed edge connectors have been replaced with multi-pin board connectors. It was, and unfortunately still is, true that most faults/problems were caused by faulty connectors between items of equipment, and by faulty, often underrated, power supplies – simple problem areas that should have been solved by now.

In those days, PCBs were laid out in a logical manner. The components were soldered in place and could be removed easily, and thus fault-finding or signal-tracing was relatively easy. Things started to change when the first computer-aided designs of PCBs were introduced. In order to reduce equipment size, circuit boards were laid out by computer to maximize the number of components per board and to increase the board's efficiency. Circuit designers allowed computers to re-design their circuits which resulted in smaller equipment but difficulty for the maintenance staff. Still, the circuit designer at least knew how the circuit was supposed to work and he or she would write a manual and/or a circuit diagram. Maintenance to component level was usually still possible, although you sometimes needed good eyesight in order to find the particular component(s).

About this time, manufacturers started a system of board exchanges. It was favoured by equipment

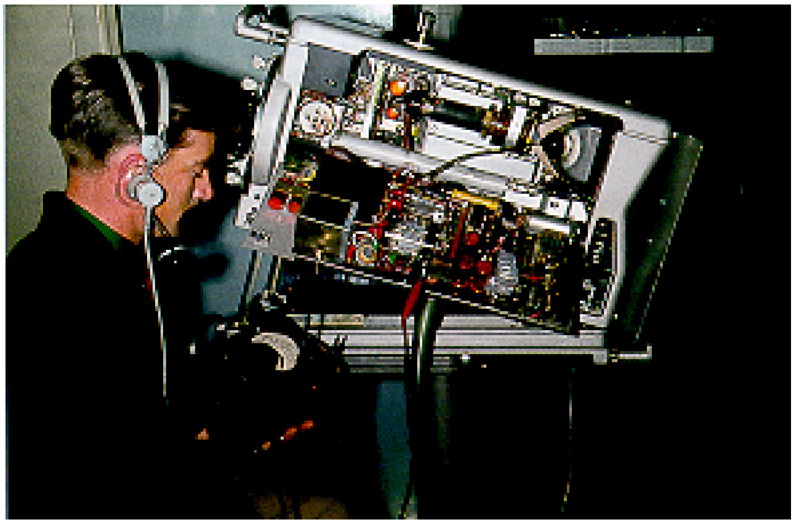


Figure 1
A studio camera in 1963.

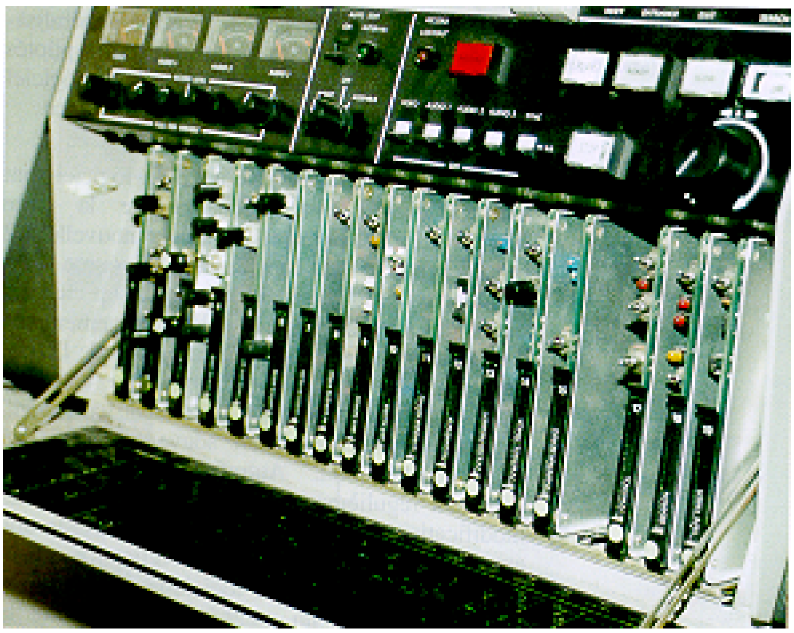


Figure 2
A row of equipment modules in the 1970s.

users who did not have full engineering support. An operational engineer – or as became increasingly common, a skilled operator – would be able to analyse a faulty unit to board level, usually by swapping boards between similar units. The faulty board, once identified, could be exchanged for a working unit on loan while the manufacturer repaired your board. In some ways, this was an efficient system. Manufacturers took on service engineers who, because they worked on the units all the time, became familiar with the faults and could repair boards very quickly.

Manufacturing techniques also changed. A further attempt to reduce the size of equipment led to the advent of surface-mounted components. It became increasingly difficult for the average in-house maintenance engineer to change components, even if the faulty ones could be identified. However the board exchange system began to fail for three main reasons:

1. Boards were often inter-related. Board A would only work correctly when Board B was working correctly.
2. Equipment became non-linear – the signal did not logically flow from A to B to C.
3. The dreaded "S" word – *software*.

3. Modern-day studio equipment

Once the boards in a piece of equipment became inter-related and the signal did not simply pass from one component to another in a linear manner, finding a faulty board became more difficult. The increasing use by TV companies of operators rather than engineers often meant that the skills to find a fault at board level were not available in-house. As many boards began to contain micro-processors and software-controlled devices, the version of software fitted in a piece of equipment became very important.

There is often a great deal of incompatibility between software levels. So, exchanging a version 4.2 board as fitted in your machine with a version 5.2 board supplied by the manufacturer becomes fraught with problems. Often, in order to allow for a software level change, it is necessary to change components in other areas of the equipment before it will work. It could be argued that this had happened before, in that equipment was often modified during its lifetime. In past years, manufacturers used to issue modification details regularly. I believe, however, that there is a fundamental difference between equipment modifications and software updates. Modifications to a VTR, such as up-rating a component to prevent it failing, does not alter the way in which the VTR operates: software upgrades, on the other hand, often do fundamentally alter the way in which the unit works.

Equipment today is often built with planned software upgrades. Vision mixers (or switchers) are often sold with knobs on the panel that have no function when it is first sold, but which become active when the software is upgraded to version 6.7 or "H" or "K". Hence, simple board exchanges no longer become possible because the level of software fitted is critical.

3.1. Software diagnostic systems

Software has developed further of course and there are some who would tell you that modern equipment with built-in diagnostic systems has made life easier for the maintenance engineer. The idea is that when the equipment is faulty you run the in-built diagnostic program and it tells you where the fault is. There are even some software companies who sell separate diagnostic systems that work with all digital VTRs. For this to work, there has to be a system of common interfaces between the equipment of the different manufacturers; this is beginning to happen slowly – it relies on co-operation between the manufacturers. However where it has occurred, I believe that it is a result of the largest manufacturer dictating what the world standard would be, rather than by means of an internationally-agreed standard. Diagnostic systems, whilst they can be useful, do have their disadvantages and they certainly don't mean that you can do away with trained engineers. I suppose one of the commonest forms of computer diagnostic software that people are familiar with is the spelling checker on a word processor. However, quite apart from the differences between American and English spelling, these diagnostic systems often get it wrong, as illustrated by this (anonymously-written) poem:

I have a spelling chequer
It came with my PC
It plainly marks for my revue
Mistakes eye cannot sea
I've run this poem threw it
I'm sure your pleased two no
It's letter perfect in its weigh
My chequer tolled me sew

Diagnostic maintenance systems often combine a record-keeping database with an error-detection system and they work only on digital equipment – the principle being that a build-up of errors can lead to the pre-detection of faults. They can be a useful tool but they are not really for the maintenance engineer in the small facilities house. The

Sony ISR system (*Fig. 3*), for example, is very comprehensive and I understand that it covers most of their range of digital equipment.

Once you have mastered it, it is a very useful tool.

The rise in digital techniques within equipment, whilst it has improved reliability considerably over analogue equipment, has caused different problems for the engineers. Due to the in-built error detection and handling in a digital machine, faults that build up are masked until the machine stops working completely. The diagnostic programmes mentioned previously are useful in that an engineer can see the build-up of logged errors and can withdraw the machine from service before complete collapse. The older analogue equipment would display signs of a fault before final failure, and the keen-eyed operator could bring it to the attention of the maintenance staff.

3.2. Maintenance service companies

A new type of company has recently been established: the maintenance service company. Some of these companies have been formed by management buy-outs of the old manufacturer's customer service department. Others are comprised of groups of maintenance engineers made redundant by broadcasters or by the closure of companies within the TV world. They came together and formed a company that provides a service to equipment users who cannot afford to, or choose not to, employ their own maintenance engineers. Several of these companies have taken the board exchange system to its logical conclusion and will loan you a complete machine whilst your one is being repaired. These companies provide a very useful service to facilities companies such as Hillside Studios.

3.3. Spare parts

It is also, unfortunately, a sign of the times that there is another type of service company that has evolved recently. Many manufacturers of TV equipment have gone out of business in recent years, and often the service agreement that you purchased such a short time ago has died with the company and, more importantly, so has the source of spare parts. Fortunately, though, there are now one or two small companies – formed by ex-customer service engineers from these failed manufacturers – who managed to obtain spare boards, parts etc. before the liquidation authorities moved in. These new companies also provide very useful support in our business.

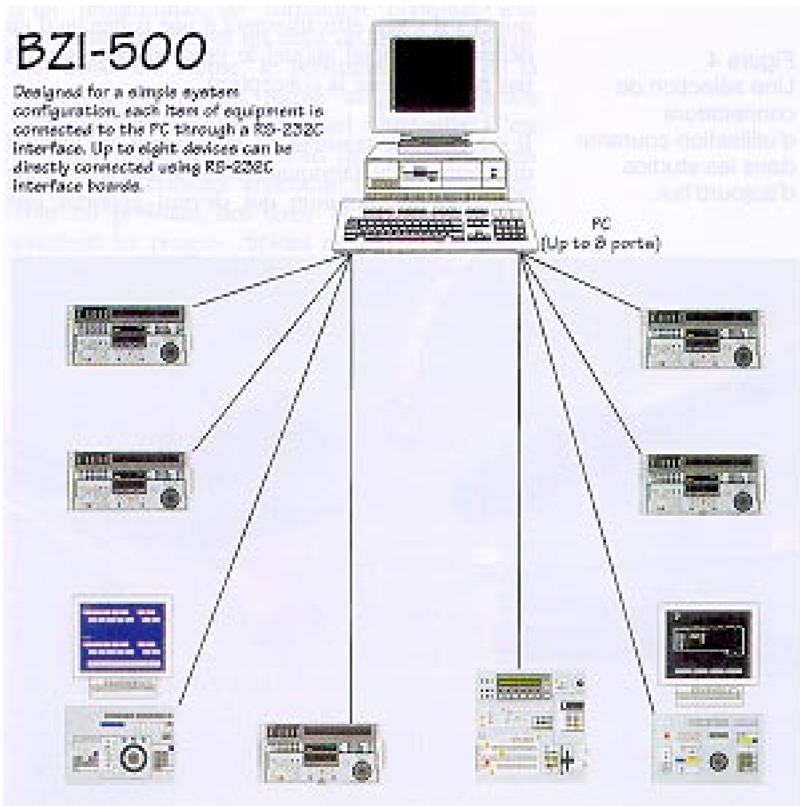
3.4. After-sales service and warranties

In the early days of broadcasting, equipment was built and tested, and when the manufacturer was happy with it, it was put on the market. Admittedly, the development time was measured in years, but if something went wrong with the equipment once sold, the manufacturer repaired it under what passed for an extended warranty. Indeed one of my colleagues in the facilities world remembers the first cameras he bought from a Japanese company. When asked about the warranty period, the company stated that they sold a camera to last for at least seven years, with the implication that it would not expect to charge for repairs within that time.

If you purchase a piece of equipment today, you are expected to purchase some form of technical or software support. Engineers are sceptical about support agreements. Maybe there is universal scepticism after it became known that the companies who sell major white goods (i.e. refrigerators, washing machines, etc.) make more money from the extended warranty insurance than they do from the retailer's price mark-up.

This concern about support agreements was expressed strongly to me by another colleague within our industry. He complained that many equipment suppliers expect companies to take out a maintenance contract for each piece of equip-

Figure 2
The Sony ISR diagnostic system.



ment. This is economically very inefficient, as much computer-based equipment seldom breaks down. It is more efficient to have an insurance policy for the replacement of faulty boards on an exchange basis. This can be done quickly and at the cost of transport only. Clearly, the manufacturers are not content with this arrangement as they stand to make far less money than with rarely-used maintenance contracts. Some manufacturers resist arrangements of this kind very strongly and try to offer cheap upgrades and options, as well as membership of a "Users' Club", whatever that means. If a user has to pay for individual contracts on a myriad of equipment, this is not an efficient use of resources. We would like to see the manufacturers either supporting the independent engineering companies, or offering a board-replacement service, or an ad hoc call-out system on a pay-as- you-go basis.

I believe that my colleague's views are echoed throughout the facilities world and probably by a lot of broadcast companies as well.

3.5. Software support

Software support companies do not seem to have really got to grips with the broadcast industry. When contacting a software help-line, there is really nothing more infuriating to a maintenance engineer than having to listen to the entire *Four Seasons* – interrupted only by "all our advisors are busy right now, your call is in a queue and will be allocated to the next spare help-desk assistant" – only to be told "Oh it does that!" when finally getting through to speak to a real person, and then finding out that the service desk only operates from Monday to Friday, betweem 9am and 5pm! One of the many areas of conflict is trying to determine what is genuinely a fault or just a software glitch that the programmer had not thought about while writing the software.

It is of course possible to download software via a modem directly from the manufacturer and this ought to make software-controlled equipment very flexible, but somehow it doesn't. There is the story about a tank in the Gulf War that had its entire guidance system re-programmed via a satellite phone link from San Francisco, so it ought to be possible to apply the principle to a simple non-linear editing system. Maybe there is a difference in ethos between computer companies and traditional broadcast engineers. Computer companies expect software to crash occasionally, we don't expect hardware to fail.

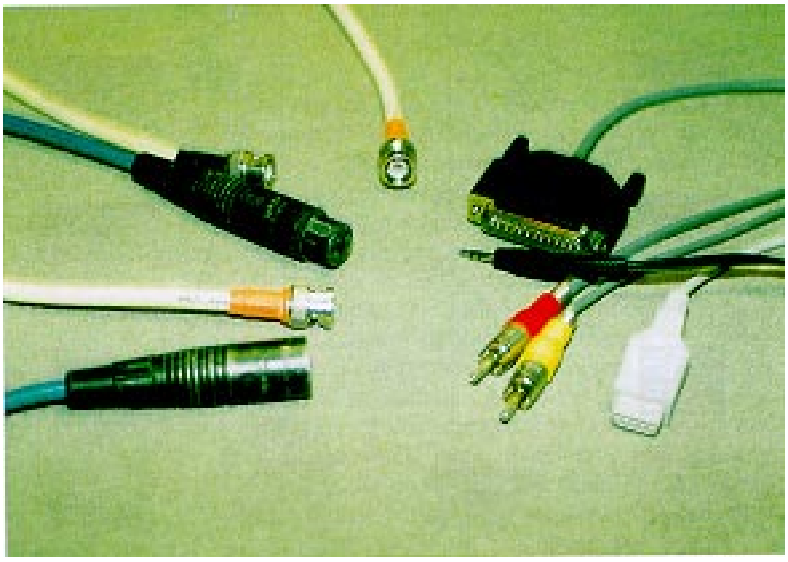


Figure 3
A selection of connectors used today in the television studio.

3.6. Other problems with computerized broadcast equipment

The increasing use of computers has seen an explosion in the variety of studio equipment available: picture stores, digital VTRs, non-linear editors, etc. It is part of the trend that where once we had a dedicated piece of equipment to do something, now we have a computer and its associated keyboard. It is certainly cheaper to do it this way, but it may not be as efficient. It is easier to press a button on a row of buttons than to enter the details into a computer using a keyboard or mouse.

On the other hand, it is true that the rise in computers within broadcasting has enabled advances in production techniques, an obvious example being graphics suites and non-linear editing equipment. However, they have brought with them their own associated problems for the maintenance engineer.

Two of the most commonly-voiced problems are:

1. Over many years, the professional TV world has developed connectors (plugs and sockets) and engineering methods that are reliable and robust. Vision signals are kept away from audio or control signals, audio signals are balanced to reduce noise, etc. These techniques, whilst they may not be cheap, have proved to be reliable. The computer industry, on the other hand, has standardized on the cheapest, smallest connectors available. They put video, audio and control signals next to each other in un-screened cables. They assume that their equipment will be installed *on* a desk and that the range of peripheral equipment will be close by. They provide short inter-connecting leads with moulded connectors. If you want to install this equipment *in* a desk in a graphics area or an

edit suite, then the leads are never long enough and getting hold of extension leads is not easy.

2. The other computer-generated problem is caused by their associated peripheral equipment. The main hate of today's engineer is the disk drive. It is simply not reliable enough. Systems such as non-linear editors, and in particular the so-called on-line versions, are working very near the limits of today's technology and are all too often let down by failures of the disk drives. The large amount of storage required by these systems – often terabytes of capacity – mean that many drives are needed. The failure of a drive, when you have just spent 24 hours digitizing your masterpiece, contributes greatly to the stress level of the modern VT editor. The rapid development of disk drives further adds to the problem; in the event of a fault, a replacement is often not available or is of a different software release, and once again the connectors are the smallest and cheapest available. The introduction of RAID technology, where the information is shared between disks, hopefully will improve things.

The standard answer of the computer industry to all these problems is *back-up*, but to have duplicate equipment standing by in case of failure is very expensive, and restoring the data to the standby system takes nearly as long as the original digitizing. And what happens in the case, as happened at Hillside Studios, when there is a failure of the back-up tape streamer? This back-up route, it seems to me, shows that we have not really progressed from the days when we had four cameras in a studio to make sure that two still worked by the end of transmission.

One other incidental problem caused to engineers by the rise in computer systems is their very cheapness. Production companies have purchased desktop equipment which the salesman assured them would be of broadcast quality. When they have had problems in trying to edit or chroma-key the material shot in a broadcast studio, they have always blamed the studio's output. It becomes difficult for engineers to tactfully point out that there is a difference between a desktop system at £5000 and a professional studio mixer costing over £75 000. "But it says it's broadcast quality in the brochure" they say.

What indeed is the meaning of *broadcast quality*? It used to mean top quality. Is the final arbiter of quality a broadcast-quality monitor? Today, there is little comparison between the S-VGA computer monitor used in a Graphics suite, capable of displaying up to 1000 lines, and a broadcast-quality monitor which, in Europe, only displays 312 lines. As a facilities company, Hillside Studios is often asked "why do my graphics look so poor on my VHS tape – they were much clearer/better in the graphics studio".

4. Conclusions

I believe that the key to the future of engineering within broadcasting is education. In the past, engineers were trained in the basic skills not only at places like BBC Evesham, but also on equipment courses run by the manufacturers. What we learned 25 years ago, whilst still relevant, has been superseded by a requirement for computer skills and knowledge. We engineers perhaps need a scheme of continuous education to meet the needs of production in the Millennium. Similarly, production staff must be educated in the technical requirements of the medium in which they work. It is by talking to each other at meetings or in print that we can co-operate in becoming programme-makers together. Whilst we can all enjoy the excitement and even the fun of the rapid evolution of broadcasting, I hope that producers, engineers and manufacturers will have an awareness of the opportunities for problem-solving that this progress will bring.

Mr Chris Hillier *joined the BBC direct from university, initially as a VTR Engineer, and later became a technical liaison engineer within the Programme Planning Department. In 1978, he joined Hillside Studios as Technical Manager, and later was appointed to his current position of Chief Engineer in which role he is responsible for the technical output, and the fabric, of the studio complex.*

During his time at Hillside, Chris Hillier has seen it grow from a training studio to a full broadcast facilities house which provides technical facilities for all the UK broadcasters. He has been responsible for the introduction of digital areas within an analogue studio centre, and has seen the increasing use of desktop television production equipment.

Mr Hillier is a Chartered Engineer and is a member of most of the UK television technical societies. Included in his duties is the reporting on new technology to the directors of Hillside Studios, and in order to do this he is a regular attendee at international television engineering conferences.