THE UK ECAD INITIATIVE 1986-1991, AN APPRAISAL

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The various aspects of establishing and running the ECAD Initiative are described. Each activity is examined critically and the changes that proved necessary as the scheme developed are charted from the scheme's inception in 1986 to the present day.

1. Introduction

The ECAD Initiative was established in 1986 to meet the needs of universities, polytechnics and colleges for electronics computer-aided design software in both teaching and research. Membership of the scheme is secured by payment of an annual fee, in return for which licences are granted for educational use of a range of industrial software packages for the design of electronic systems. The design needs covered include structural and behavioural circuit description with linear and digital simulation, test analysis, alternative implementations including programmable devices, gate-array and full-custom integrated circuit layout, printed circuit board layout, electronic system documentation and computer aided software engineering. The membership fee covers the cost of software updates and documentation, also support, either directly by the supplier or indirectly by a Lead Site. A Lead Site is an educational establishment with the necessary expertise and training to act as an interface between the software supplier and the academic user. Most of the software is distributed through a central site which also provides administrative and financial control services for the scheme.

During the five years 1986-91 the ECAD Initiative was administered by the University of Manchester. In July 1991, this role was passed to the Rutherford Appleton Laboratory (RAL), an establishment of the Science and Engineering Research Council (SERC) and based at Chilton near Oxford. The scheme is entirely self-funded and the stable membership of over 90 institutions is an indication of the strong commitment to continuation. Not surprisingly however it has proved necessary to make many changes to the ECAD Initiative during its five year life. This paper will therefore identify the original concepts, aims and operational methods adopted, chart the changes that proved necessary as the scheme evolved and finally appraise the overall effectiveness achieved in improving standards in electronics design education.

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2. The Origins of the ECAD Initiative

In March 1984, a conference at the University of Hull ('Electronic engineering - the way ahead') revealed that higher-education establishments were producing no more than about 100 graduates each year with sound training in integrated circuit design methods. It was further recognised that this sparse output if continued would have a serious impact on the capability of the UK electronics industry to exploit the new opportunities for innovation and product improvement offered by application specific integrated circuits (ASICs). Two working parties were thus established representing the university and polytechnic sectors respectively. Both working parties reached the conclusion that the gravity of the problem clearly called for a solution on a national scale and thereafter agreed to work together. The common aims were to procure professional CAD and to establish low-cost routes to integrated circuit manufacture for teaching purposes. However, there remained a broad spectrum of differing opinions on the means whereby the common aims should be achieved. The diversity of views was also apparent at subsequent consultation with representatives from universities, polytechnics, semiconductor manufacturers, CAD suppliers and industry-based design centres.

Most of those consulted agreed that computer aided circuit description and simulation have the greatest educational worth, also that motivation is strongly enhanced if designs can be implemented. Indeed, many held that if the lessons of designing for testability are to be fully understood, then circuits must be fabricated. Areas of less unanimity were the requirements for mask-level design and the suitability of commercially available software for undergraduate use. However on balance it was agreed that there was merit in student exposure to the silicon technologies and CAD systems used in industry. The working parties therefore concluded that the requirements were for fully supported industry standards in software and computer hardware for design and in commercially available silicon manufacturing processes for implementation. There followed a series of negotiations for favourable discounts from computer hardware manufacturers, software suppliers and silicon vendors. The CAD case was accepted and funds totalling 8 million were allocated by the University Grants Committee (UGC) on behalf of the universities, by the Department of Trade and Industry (DTI) on behalf of polytechnics and colleges and by SERC on behalf of the research community. About 1.6 million was spent on the central purchase of software and the remainder was distributed through grants to educational establishments to purchase suitable computer hardware. Since neither set-up costs nor recurrent funding were provided to establish a support service organisation it was very much an act of faith for the University of Manchester to undertake administrative and financial responsibility for the scheme.

However, by late 1986, the contractual issues with suppliers were settled, Lead Sites were established and the first membership fees were collected from the 90 participants. The Higher Education ECAD Initiative had begun and within six months the initial software purchases from Silvar-Lisco, Genrad, Racal-Redac, Praxis and Qudos were in great demand with over 500 workstation nodes and 80 minicomputers

registered. Due to lack of funds the proposed central coordination office serving needs in fabrication never in fact materialised. Instead, effort and resource was applied to maintaining CAD links to low-cost device manufacture, principally for gate-arrays, for which institutions dealing directly with the supplier proved entirely satisfactory. For full-custom design implementation a valuable coordination role has been played by the University of London VLSI consortium. Thus, to a large extent the original aims of the initiators of the scheme for professional CAD and chip fabrication to be made affordable for use in teaching and research were achieved.

3. Mid-term Enhancements

The principal omission from the initial software purchase was support for analogue circuit design. The injection of further capital in 1988 made it possible to include Interactive Solutions, Meta-Software and EEsof as suppliers, thus bringing in analogue circuit capture and simulation together with microwave and high-frequency circuit design.

Also in 1988 more software from Qudos included the larger Texas Instruments gate-arrays. A gate-array design suite from Micro Circuit Engineering was added and SOLO 1200 was purchased from European Silicon Structures. These particular acquisitions strengthened the capability for silicon design by providing simple to use, well integrated and dedicated tools for specific implementation technologies. The aim was to encourage institutions to close the loop on teaching design through fabrication and test. As a further incentive, a scheme was established whereby silicon fabrication costs incurred for education purposes were reimbursed at 50%. Very soon over 100 gate-arrays and about 50 full-custom chips were being manufactured annually for student projects.

4. Changes in Funding Policies 1988-90

It soon became clear following restructuring of the funding councils for universities, polytechnics and colleges that there was no longer a mechanism to pump-prime schemes such as the ECAD Initiative with further capital. Yet it was becoming increasingly urgent to modernise the software portfolio to match changing user requirements. The membership subscription had originally been set at 3300 per year and was raised only to keep pace with inflation to ensure a margin just sufficient to cover the cost of maintenance and administrative support. It had therefore not been possible to build up a capital reserve of any significance. The current annual subscription (1991-92) stands at 4500.

New software was needed to design programmable logic devices and to provide an alternative to Silvar Lisco for general purpose applications. The importance of the IBM-PC as a CAD hardware platform had also been recognised. Unlike the original software purchases which were selected by an expert panel to match an operational requirement derived from questionnaires, these new packages were specified much more directly, from experience gained by individual institutions in the user community. For example, there were about 20 user sites for Mentor Graphics prior to the software

being added to the ECAD portfolio; within 18 months, the number of Mentor sites has increased to 60, clearly justifying the decision to include Mentor Graphics in the scheme. Over the same period, use of Silvar Lisco declined to a level where it became no longer economic to continue support.

Thus, in the absence of a capital subsidy, suppliers were asked to consider offering site or seat licences at prices which were easily affordable by educational establishments with serious interests in electronics design. It was understood that the ECAD Initiative would bear the cost of future maintenance of such purchases, just in the same way as it had for the original portfolio.

Older less useful packages were dropped so as to make way for the new without increasing the overall outgoings paid in maintenance to suppliers. This programme of modernisation of the ECAD software portfolio took place over a two-year period starting late in 1989. The changes are evident in Table 1.

Table 1. ECAD Initiative software portfolio 1988-91.

1988	1991	
Silvar Lisco	Mentor Graphics	Viewlogic
HILO	System HILO	OrCad
Ella	Ella	Xilinx
Isis	SOLO 1400	Actel
SOLO 1200	MCE BX	
MCE BX	Qudos Quickchip	
Qudos Quickchip	HSPICE	
HSPICE	Minnie	
Minnie	EEsof Family	
EEsof Family	Cadstar	
Redcad	PHASE 1/2	
SMS cell library	Chipwise	

5. ECAD and EUROCHIP

Towards the end of 1989 as a result of a 25 MECU ESPRIT action on VLSI skills training, the SERC Rutherford Appleton Laboratory was designated as a EUROCHIP service centre for a scheme which shared many of the features of the ECAD Initiative, including educational licences for software and grants for computer purchase. Also, the action identified 38 UK educational establishments to receive varying levels of free access to silicon fabrication. Software licences would be available at nominal costs to any educational establishment wishing to participate. The portfolio of software offered by EUROCHIP showed significant overlap with that of the ECAD Initiative and it was clear that many UK educational establishments would like to be able to take advantage

of both schemes. It was therefore agreed in June 1991 that the Rutherford Appleton Laboratory should take over the responsibility for the ECAD Initiative and thus ensure that it continued to develop in a complementary fashion to EUROCHIP. The immediate practical aspect of this decision was that educational establishments requiring access both to ECAD Initiative software and to EUROCHIP services had to pay only a single subscription at the former ECAD Initiative level to the new combined scheme.

Thus, during a transitional year August 1990 to July 1991 administrative responsibility for the ECAD Initiative was transferred from the University of Manchester to the Rutherford Appleton Laboratory (RAL). The transfer was in fact achieved on time and indeed, orders and deliveries were being undertaken by the new administration about six weeks prior to the planned deadline. Already members are enjoying the benefits arising from the combined scheme, such as the rationalisation of support for packages common to EUROCHIP and ECAD where now a single point of contact can deal with contract enquiries, distribution requests and technical problems. The subcontracting of support by Lead Sites has thus been reduced with a consequent saving in cost to the scheme and an improvement in service. Whether similar benefits would accrue if more of the support duties were undertaken by RAL is open to question since clearly if Lead Sites continue to provide value for money there is no reason to change the current arrangements.

The future of the combined ECAD-EUROCHIP scheme at RAL looks attractive in providing a cost-effective service for its members. Through EUROCHIP new funding seems possible for upgrading or adding to the software portfolio and the coordination of routes to affordable integrated circuit fabrication is likely to remain. The ECAD Initiative can look to enhancing its software portfolio in areas not covered by EUROCHIP but of particular interest to the UK, maintaining support for a broad range of CAD tools rather than those just for VLSI.

6. Management and Administration 1986-91

At the start of the ECAD Initiative a Management Committee was established comprising university and polytechnic nominees together with representatives from the co-sponsoring organisations (UGC, DTI and SERC) and also from the governing body for polytechnics, the National Advisory Board. The terms of reference of the Committee were to monitor and develop the scheme generally, to ensure the effectiveness of the Lead Sites and to advise the University of Manchester on expenditure and on the setting of annual fees. Thus, the University operating through the ECAD Office in the Manchester Computing Centre provided central services to collect membership fees, issue software licences and distribute software media and documentation.

Under the direction of the Management Committee administrative procedures evolved to meet the changing needs of the user community and suppliers. In particular, effort was applied to ensure that long delays between requests for software and shipment of media were virtually eliminated. Various databases were established to

link for each user site the ECAD representatives, software deliveries and computer nodes registered. It thus became a relatively straightforward task to provide the Management Committee with statistics on the uptake of particular software packages. The Manchester Computing Centre also undertook a major proportion of the documentation copying and distribution at costs well below commercial rates.

Thus, in achieving a primary aim to minimise costs to the ECAD Initiative, the decision to base the administration in a major National Computing Centre was substantially correct. There were however some shortcomings which can be attributed to the difference between providing general computer services and application software distribution. The main causes for user dissatisfaction were failures in communication with the ECAD Office staff on technical issues such as authorisation and installation problems. Such problems would have found a much quicker solution if the user had been able to talk directly to the supplier concerned. The Computing Centre did not have sufficient resources to test a new version of software on every computer type before distributing tapes to users. Neither was it feasible to search through long lists of authorisation codes to verify that all nodes for a particular site had been included correctly. The net effect was that for some sites there was a frustrating period of delay sometimes extending for several weeks before working versions of new releases could be up and running. The situation became further complicated by the decision of several suppliers to put time-bombs in their software in addition to node authorisation codes, thus affecting sites who for various reasons did not wish to run the latest version of a package. These cumbersome authorisation procedures adopted by suppliers imposed a considerable workload on the ECAD Office and were a perpetual source of irritation for users. It is hoped that the new administration at RAL can put pressure to bear on suppliers to operate a more flexible system of authorisation for educational sites.

The newly formed ECAD Steering Committee which will direct the joint ECAD_EUROCHIP support organisation run by RAL has a clear remit to ensure the best possible service for the UK educational sector by developing access to both National and European facilities in microelectronics. The Steering Committee has been chosen to represent the educational community much more fully than the former Management Committee by having 50% of its membership elected thus giving a strong voice in future policy decisions for those who use the software and wish to see good value for their annual subscriptions.

7. Software Procurement and Replacement

The functional and operational requirements for electronics CAD software were first specified in 1985 from surveys conducted by the universities' and polytechnics' working parties. Details of this specification were subsequently published (Jones, 1986) and were the basis of an invitation to tender issued to some 20 suppliers. It was implicit that the requirements should be met ideally by a suite having a common front end for design capture for both analogue and digital circuits, well integrated simulators and clearly defined paths to integrated circuits by semicustom approaches such as gate-array and standard cell. The software offered had to be available on a range of different computer types.

It was this tightness of specification that made Silvar Lisco the inevitable choice as major supplier to the ECAD Initiative. Only later did the poor degree of integration of Silvar Lisco tools become apparent, leading eventually to their virtually complete surplantation by the Mentor Graphics suite. Even today therefore there is a clear desire by many educational establishments to lock their ECAD needs to a single major supplier and to run the software on a single computer type. The reasoning is that the average student should not be expected to learn more than one CAD system during the 3 or 4 years of an undergraduate course. However, as indicated by the variety of software in the ECAD portfolio it is widely recognised that point solutions have their place and are indeed generally better suited to student use where rapid learning of specific route to implementation is needed. Typical examples of good point solutions are CADSTAR for PCB design and MCE-BX for gate-array design; both tools are quicker to learn and apply than the corresponding modules within the Mentor suite but unlike Mentor, neither can offer advanced facilities such as board level and system level simulation.

There have been changes in computer hardware in the past five years to diminish the relative usefulness of multi-user minicomputers and to increase the power of IBM-PCs or compatibles for CAD applications. The power of workstations has increased 50 fold in the same period and the market balance fluctuates between computer types as each manufacturer strives to excel in price-performance for their products. The net outcome is that software vendors are now much more likely to put effort into porting to a wide range of workstation platforms. Thus for future ECAD Initiative procurements, the functionality of the software will override any importance its hardware availability may have assumed in the past.

All the later additions to the ECAD software portfolio were as a result of user demand feeding both requirements and direct experiences into an expert panel established by the Management Committee to investigate a particular need. In some instances, a panel has been called upon to make recommendations for replacement or discontinuation of current packages. The volume of requests for updates is perhaps the best indicator of the popularity of a package and so it became standard practice for the ECAD Office to issue new versions on request only rather than automatically. More detailed information on the effectiveness of a particular tool is frequently flawed. A recent example of this was a result of a poorly designed questionnaire which incurred such a vitriolic response from non-users that the positive replies were virtually obscured. The lesson is that if a questionnaire is to be used, considerable care must be exercised in its design to elicit useful information from active users only. The questions must be few and simple, otherwise people will not expend effort on a reply; thus to ask how many student hours per week and how many workstations are dedicated to using a package and for what purpose is it applied etc., will undoubtedly prove less effective than a simple yes/no box indicating a desire for continuation or not, together with space for comments as necessary.

The move to individual sites purchasing licences at discounted rates which came with the newer additions to the ECAD software portfolio was a regrettable but inevitable outcome of a failure to attract the significant capital funding required for a central

purchase on behalf of all members of the scheme. Seat licensing introduced at the same time has caused high administrative overheads and has proved a serious inhibition to the rapid uptake of new software. It is therefore hoped that future negotiations will take into account the need to offer a site licence option where the benefits of the resulting high levels of utilisation should be a self evident incentive to the supplier.

8. Lead Sites

These were established initially to spread the burden of software distribution and to provide a buffer between the software suppliers and the user community in respect of technical support and basic training. The mass training provided by suppliers at the start of the ECAD Initiative was not a success mainly because the software did not become available at user sites until many months later. Smaller courses held subsequently at Lead Sites proved to be very much more effective although the need to charge attendees was seen to have an adverse effect on uptake. It is significant that training courses organised free of charge by RAL continued to be well attended whereas courses at Lead Sites saw a declining uptake as time progressed, even though the facilities offered were similar and professional trainers were employed in each case. The conclusion to be drawn is that most educational establishments cannot afford training fees, even for as little as 70 per day. A further observation has been that once a new package has become established, certainly within a year of its introduction to the scheme, the demand for training falls rapidly. Also, for most of the simpler tools, now that most sites are well experienced in the use of a wide range of different ECAD applications formal training is not required and the training manuals provided by the supplier are usually sufficient.

The technical support requirements also changed as users became more experienced and so Lead Sites were required to become more specialised in respect of the packages for which they were responsible. About the same time it became clear that software distribution should be centralised rather than devolved to Lead Sites. A central distribution service was therefore established in 1988 operating through the ECAD Office at Manchester, thus providing strict control and monitoring of software take-up. The Lead Sites were then able to concentrate their efforts on providing a higher standard of support, with each site responsible for only 1 or 2 packages rather than the full range, as was the case initially.

Even with the reforms, the Lead Site operation still suffered serious shortcomings in respect of the depth of problems which could be tackled quickly and effectively. It was found impossible to retain continuity of adequately trained staff in low-salaried posts and on short-term contracts. Recent changes to the Lead Sites arising from the ECAD_EUROCHIP merger include a movement of a greater proportion of package support responsibility to the central site at RAL where hopefully the staffing position will be more stable. Significantly, however, Mentor Graphics are to continue direct support of educational establishments who are members of the ECAD Initiative, believing as they do that the benefits of the relationships thus formed far outweigh the extra burden on their customer support organisation.

Several other suppliers of software to the ECAD Initiative also provide direct technical support to users but with the ECAD central administration undertaking the distribution of media and documentation. This in many ways appears to be an ideal arrangement in that a good technical relationship is developed between the supplier and the academic user community yet the potentially costly burden to the supplier of distribution and contract administration is devolved by making use of the central services. In negotiations with new suppliers in the future this alternative to Lead Sites must certainly be an option to be discussed.

9. Fabrication Support

Although the establishment of access to low-cost integrated circuit fabrication was a major feature of the early negotiations by the universities' and polytechnics' working parties it was initially rejected by the funding bodies. This rejection was not primarily on grounds of cost but more on philosophy. The advice from industry at that time was that only the use of CAD tools was important and that a fabrication service for academia was neither necessary nor economically viable. It was simply not accepted that the opportunity to see individual designs through to manufacture would prove to be the major motivating factor to inspire a commitment to student use of CAD tools. It is regrettable in retrospect that the arguments for a fabrication service could not have been made more convincing in 1985. Since that time, the ad-hoc arrangements made by Higher Educational Institutions (HEIs) with individual suppliers have more than proved the point that fabrication is both necessary and affordable. Thus, it was no surprise in 1989 that the emphasis within the ESPRIT action on VLSI was very much on the provision of high quality central services to support routes to integrated circuit manufacture for all HEIs who could demonstrate a need.

However, for members of the ECAD Initiative, following the initial set-back in 1985, it was not until 1988 that the DTI recognised that fabrication and test of student designs formed an essential element of training for industry and established a three-year 50% refund programme to encourage HEIs to have chips manufactured. When this scheme was first proposed it was necessary to survey the likely demand so that an adequate budget could be set. Members of the ECAD Initiative were therefore circulated with a questionnaire to determine interest in a 50% subsidy and to discover what technologies would be required. A separate enquiry revealed from a study of UGC and CNAA statistics that there were about 4500 students in each year of degree courses for whom the proposed scheme would have relevance. Potential suppliers were also contacted in order to obtain realistic pricings for gate-array or full-custom chip fabrication. Target prices were set of 400 for gate-arrays of 1000 gates and 100 per square millimetre for 3 micron CMOS full-custom processing. Three silicon suppliers, who were also providers of software to the ECAD Initiative, showed a keen interest in the proposals and indicated that they were willing to deal directly with HEIs, thus making the need for a central coordinating site unnecessary.

Procedures were established by the ECAD Office at the University of Manchester to vet claims, approve suppliers and to distribute refunds. Usually a turnaround from claim to remittance of no more than two months was achieved.

Within the first year of operation 37 sites had spent in total 69,000 on silicon fabrication. Prior to the refund scheme, no more than 10 of the members of the ECAD Initiative had taken designs to manufacture. Some 20% of the claims were for over 1000, which gave a strong indication of the commitment by departments to ensure that IC design teaching is properly supported by including test and evaluation for at least some of the student designs. From the invoices submitted for authorisation an estimate was made of the yearly totals for participant institutions, gate-arrays and full-custom designs as shown in Table 2.

Table 2. Take-up of silicon fabrication.

	Estimated from User Survey	Actual 1988-89	Actual 1989-90	Actual 1990-91
Participants	47	37	32	36
Gate-Arrays	480	100	150	232
Full-Custom	57	40	78	97

It can be seen that the actual use in all three years fell short of the estimates except for full-custom chips, which also showed a steady increase over the period. Thus, although the figures indicate that use of fabrication multiplied as a result of the DTI refund, the level of subsidy was not sufficient for the majority of departments to achieve their target needs. The EUROCHIP scheme has introduced a free allocation of silicon fabrication which will almost certainly lead to a greater number of student designs for full-custom technologies being manufactured. The outlook for gate-arrays is however uncertain because these are not supported under EUROCHIP. Also, there are now available programmable gate-arrays. These new devices offer speeds, complexities and design styles very similar to conventional gate-arrays but their reprogrammability makes them more suitable for teaching purposes since they eliminate fabrication delays and reduce costs. It therefore seems probable that in a short time, HEIs will abandon the use of the standard gate-array for teaching purposes. The ECAD Initiative must therefore look to modifying its software support accordingly.

Even so, the standard gate-array has provided valuable service in the past three years. The designs implemented have in general been more application orientated than those in full-custom. Indeed, many of the projects involving gate-arrays have arisen through industrial sponsorship. The replacement of such devices in future student implementations by field programmable gate-arrays (FPGAs) is welcomed as being in line with current industrial trends. Gate-arrays which embody mixed digital and analogue functions are not currently available in field programmable technology and so must continue to be supported both in respect of CAD software and routes to low-cost manufacture.

Only 38 HEIs applied to participate in the ESPRIT VLSI training action and of these only 10 could be considered to be heavy users of the DTI refund scheme. Since in the three years of operation DTI refunds were allocated to over 60 HEIs, the mismatch to the EUROCHIP provision was significant. The decision of the EUROCHIP Steering Board to invite all HEIs to join the scheme and thus benefit from the integrated circuit fabrication services is therefore especially welcome within the United Kingdom.

The take-up of fabrication has been significantly greater by universities than by polytechnics or colleges. During the three-year DTI programme, 76% of universities had devices manufactured whereas for the remainder of HEIs, the take-up was 62%. This difference is a clear reflection of the resources available for such purposes in the two types of institution. Recent changes in funding policies by the respective funding councils will however almost certainly reduce recurrent expenditure by universities in their teaching programmes to bring their cost per student more in line with levels achieved in polytechnics and colleges.

10. User Group Activities

The original concept of a multi-faceted user group structure as proposed by the founders of the ECAD Initiative did not in fact develop as anticipated. It had been thought that regional groups, possibly based on Lead Sites, together with suppliers, would be the norm. What has emerged instead is a single national user group with both users and suppliers contributing to workshop events and to newsletters. Suppliers no longer find it necessary to segregate their academic and industrial users and the joint participation of educational and industrial representatives in supplier specific group meetings has obvious benefit to all concerned. Meetings at Lead Sites have thus virtually ceased. There is little doubt that the users are well served yet not overwhelmed by the frequency of meetings.

The ECAD Educational User Group (EEUG) Committee oversees all user activities and has a strong interaction, recently formalised, with the ECAD management body. The bulk of the EEUG Committee's work relates to organising the twice yearly workshops. These are normally one-day events where the programme is focused on a particular theme for which expert speakers are invited. Time is also allocated for presentations from the ECAD administrative team and from the management. The occasions thus have a useful technical content combined with the communication and discussion necessary to ensure the current support operations are acceptable and that future management policies are fully understood. The EEUG Committee also acts as an editorial board for a Newsletter which is published three times a year and to which contributions are invited from the ECAD management and administration, suppliers, Lead Sites and from the user community.

The pattern of organised user activities which has evolved during the initial five years of the ECAD Initiative looks set to continue. It is self-financing through its workshops which are both well attended and lively events. Rotation of Committee membership is built into the EEUG constitution and so a regular renewal of outlook and ideas can be expected to maintain its currently healthy position in the years ahead.

11. Conclusions

The level of success achieved in five years running the ECAD Initiative programme can be identified in the continued willingness of over 90 HEIs to contribute their annual membership subscription. The members clearly see value for money and in simple statistics this is shown by over 50% active uptake of major packages, continued registration of new workstations and a high activity in silicon fabrication.

The educational benefits of the ECAD Initiative are much more difficult to quantify. It is too simplistic to state that a high proportion of the 4500 electronic engineering graduates have had real design experience using industrial standard CAD tools without a balancing statement from the electronics manufacturing industry to support the view that such experience is of lasting value. Unfortunately, within the United Kingdom academia has been ahead of many of the broad based industrial companies in the acceptance of CAD methods for electronics design. It may therefore be some years before graduates who have had CAD experience are in positions sufficiently senior in such companies to voice their views on whether or not it was worthwhile.

In the smaller equipment manufacturing companies the investment in CAD is rarely sufficient to complete ASIC designs in-house and so such work is usually subcontracted to specialists. There is no doubt that such specialists welcome new graduates with CAD skills over a broad spectrum. It is therefore very important that HEIs should develop links with these new ASIC design companies to ensure that what is taught is not only relevant but also good design practice. The CAD vendor 'user' meeting where there is significant attendance from industry is the ideal forum to foster such relationships.

The best testimonials to the success of the ECAD Initiative come from companies who are at the leading edge in developing telecommunications and computer equipment. They demand excellence in their graduate intake and typically assume that basic concepts in design have been properly introduced. It is therefore pleasing that the evidence in published experiences in ECAD teaching (Jones and Buckley, 1989) is in the main on design methodologies rather than simply on use of tools.

The merged ECAD-EUROCHIP programme now goes all the way to satisfying the original aims of the ECAD Initiative in the provision of industrial standards in CAD, a fully supported and subsidised route to IC manufacture, and by negotiation of substantial discounts for workstation and tester hardware. Given the opportunities arising from the European Community links combined with the enthusiasm and commitment of the membership, there is every prospect that the joint scheme can look forward to a future of continuing progress and development.

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