ALVEY SOFTWARE ENGINEERING— a strategy overview

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1. INTRODUCTION — This paper sets out to inform those organisations and individuals within the IT community of the aims of the Software Engineering Programme; the directions that it proposes to follow; how the Directorate will seek to manage the programme; the relationship that the programme will seek to build with ESPRIT and finally outlines the key points of justification for the proposals set out in this document. An important aim of this paper is to establish an understanding of, and to seek comments on, the strategy outlined below.

This paper is not a plan but aims to establish an overview of the strategy proposed. Detailed plans will be developed in the course of the programme to cover each area of work and a more comprehensive coverage of the main programme areas is available as a companion paper for those specifically interested and engaged in Software Engineering. In short, this is the first issue of the Alvey Software Engineering manifesto designed to inform the IT community of the Directorate's intentions; to promote informed comment and hopefully establish widespread support.

2. AIMS — The programme will set out to establish tools and methods necessary for the production of high quality, cost effective software of world leading standard. It will be concerned with all stages of the software life cycle. Of equal importance the programme will seek to foster attitudes within UK management and their software staff that will regard their use as normal practice.

In pursuing these aims the programme must recognise a number of important issues —

- that in many areas existing market and economic conditions will be more significant than considerations of technical excellence.
- that the programme cannot sensibly develop a position that makes the UK totally independent of non UK products and components. It will, however, aim to minimise this level of dependence and establish strategies for "managing" the residual level, not only to keep down the UK import bill but also to make the UK less vulnerable to problems of access and supply.
- that much good work will be done outside the UK not least as a result of the major programmes being undertaken by the USA and Japan. The programme will need to maintain a sensible balance between "in house" work and "buying in" subject to the observation above. Overall there will be a preference for importing ideas and methods rather than products.
- that the need for good levels of collaboration has been strongly emphasised in the main Alvey report. The Software Engineering Programme will fully support this position.

Although the aims of the programme are wide in scope and will of necessity show results over a substantial period of time, means of measuring its effectiveness will be sought. As yet it is early days but a number of potential measures are indicated —

- a track of the UK software import bill and particularly that element covered by "tools".
- the establishment of a mechanism that will assess the level of capital employed in the area covered by productivity and quality tools on a capital per programmer basis.
- the programme will seek to establish formal techniques for the measurement of software output both in cost and quality terms. These techniques will be applied on a continuing basis to measure the progressive levels of improvement achieved by the use of successive generations of tools and methods.

Overall the aim is to provide within the UK, in the next decade, an infrastructure for the production of software that will support UK industry in a manner similar to that provided by Japanese Steel to Japan's Manufacturing Industries in the 1950s and 60s.

3. MAJOR COMPONENTS OF THE PROGRAMME — The consultation that took place as a preliminary to the production of the Alvey Report, and subsequently reconfirmed in recent informal discussions, showed that there are strong levels of agreement in Industry, Government and the Academic Community on the main directions the programme should follow. Three vital objectives are identified —

(i) Exploitation — efforts are needed to ensure that existing methods are effectively used and their benefits gained by industry as a whole. Additionally, continuing efforts are needed to bring the fruits of research out into industrial use, with the associated investment and training.

(ii) Integration — work must be directed to establish the development of integrated methods and sets of tools for hardware and software development covering all phases of the system life cycle. The focus for such work will be the production of the Information Systems Factory (ISF) in which the UK will aim for technical leadership.

(iii) Innovation — programmes of research and development will be needed to extend the methods and techniques of software engineering. In particular this set of programmes will serve to establish a sound basis for the work undertaken in the ***Integration*** and ***Exploitation*** activities.

In order to give an overview of the activities covered in the programme, together with the relationships that will exist between ***Innovation, Integration*** and ***Exploitation***, figure 1 shows the process of system development subdivided into the following elements —

Methods and processes — how things are developed

Management — the monitoring and control of the methods and processes

Environment — the work place, tools and equipment used.

The work envisaged as necessary for the fulfillment of the objectives listed above is explored in more detail overleaf. As indicated in the Introduction, this is intended primarily to identify the main directions that will be followed rather than to define a detailed plan of action.

Figure 1

STRATEGY / DEVELOPMENT ELEMENT	Innovation and Understanding	Integration and Implementation	Exploitation and Evaluation
Methods and Processes	Specification V & V Reliability Quality Reusability Metrics	Blend techniques into life cycle method for both hardware and software	Measure Use of Integrated Project Support Environments (IPSEs)
Management	Models of development and maintenance processes and methods	Integrate development methods with management techniques	Evaluate use of IPSEs
Environment	Influence on Productivity and Quality. Relationships with other technologies eg MMI, IKBS	Build Integrated Project Support Environments (IPSEs)	Make IPSEs available via Centres

Exploitation

There is general agreement that great scope for improvement in software quality and productivity can be achieved in the short term by encouraging the widespread acceptance and use of even simple tools eg, data dictionary systems, test harnesses, project databases, etc, of the kind currently in use in the more "leading edge" environments. Three things are needed to bring these improvements about:

(i) provision of sets of tools each in a standard compatible form, well supported and built to good standards.

(ii) encouragement for the capital investment in the necessary equipment and training.

(iii) education of both management and software staff; management must be shown that investment does pay off, and software staff must be educated in the systematic development and production methods that enable the tools to be used cost-effectively.

The above will be areas of priority in the near term. Good work is already taking place, addressing a number of these topics. The Software Engineering Programme will seek to encourage such work, fill current gaps and provide better levels of co-ordination and focus.

In the longer term the programme will seek to identify and encourage better and more formal mechanisms aimed at closing the "development gap" between research and productive use. In particular, the role that might be played by the major public purchasers and their suppliers would seem to be of clear relevance, together with clearer and more formal specifications of standards to be employed.

Overall the Exploitation programme will seek to confirm the need to invest in productivity and quality aids. It will aim to provide management with a view of the benefits and implications of introducing these methods into their organisations, and will enable staff, who will operate within this environment, to have early experience of their operation and, as a result, provide valuable "feedback" to both the designers of the systems and their management.

Trials and demonstrations on a realistic scale will be run at "Software Production Centres". Additionally work will be put in hand to examine the implications of software quality and certification with the aim of establishing one or more "Quality Centres".

Integration

The second major need identified is for ***Integrated*** project support environments. The common understanding of an integrated PSE (IPSE) is that it should contain a compatible set of specification, design, programming, building and testing tools supporting a development methodology that covers the entire life cycle, together with management control tools and procedures, all using a co-ordinated and consistent project database. What is more, given the certainty that no one particular programming language will emerge in the medium term accepted as a standard meeting all needs, such PSEs will require multi-language capabilities. The position is further reinforced by consideration of the considerable levels of investment already made in the programming languages of the 1960s and 1970s.

Similar considerations apply to mixed hardware and software systems. It is clear that there are enough and increasing similarities between the hardware and software design processes, and the administrative and management procedures appropriate to them, for there to be benefit in aiming, in the longer term, to use one PSE for both hardware and software development. Furthermore, it is important that the requirements analysis, functional specification and much of the design work can be done independently of decisions whether particular modules should be implemented in hardware or software. For such modules, their function must be defined, their place in the overall design established and their performance requirements known; economic, timescale and other criteria may then be used to determine how they should be implemented.

A fully integrated PSE as just described is exactly the Information Systems Factory, which is the focus of this programme. It is a long term objective for the end of the decade. It is, nevertheless, important to be clear about what the objectives are in order to see how to move towards them, and in particular to determine the role of Unix and Ada APSE developments in this process.

The Software Engineering Programme will include one or more evolving PSEs which not only bring together existing tools and procedures to improve development cost-effectiveness in the shorter term but are also capable of incorporating new techniques that emerge from relevant R and D projects.

Unix will be used as the basis for

(i) the "exploitation" tools propagation exercise

(ii) the first generation (file based) IPSE.

Unix is rapidly becoming a de facto standard over a very wide range of systems and organisations and therefore offers the prospect that

- there will be many developments for Unix which can be taken advantage of by the Alvey programme
- the market for Unix-based development environments and tools is large and growing. These factors should minimise the amount of tool integration and development needed to improve today's Unix generation IPSE.

The second generation IPSE contains two major components not found in the first generation IPSE:

(i) database-based tool set (rather than file-based) eg as illustrated in CADES

(ii) distributed project support, eg as illustrated by the "Newcastle Connection"

As (i) and (ii) above are somewhat orthogonal it is expected that several approaches will be attempted. One will include the evolutionary development of the first generation Unix-based IPSE. A second approach will involve a "clean sheet", non-Unix attack.

The third generation IPSE (or ISF), containing knowledge base and "intelligent" tools, requires significant research which must begin now, if the 1989 target date for the Information Systems Factory is to be made.

Thus the strategy for producing the three generations of IPSE requires a controlled set of concurrent and overlapping research and development activities. It is important that the first and second generation IPSEs are produced, because major gains are expected in software productivity and quality from their UK installation and exploitation, as well as export sales.

The IPSE strategy proposal does not seek to establish Unix as a long term Alvey standard. It does, however, recognise that at this stage there is a need to establish a starting point which stands a chance of gaining general acceptance and having a wide relevance in the market place. It is clear that further work will be needed to protect against an undue level of dependence on the Unix base. Two lines will be developed.

(i) An examination of environment portability

(ii) A vigorous drive to assist in establishing sound standards that will allow us to define more precisely our dependence and as a result, enable us to manage this dependence in a more systematic and positive fashion.

The need for early use and evolutionary potential rule out direct incorporation of the Ada APSE within the programme. It is clear, however, that much common ground will exist between the two projects and the Alvey Programme will, as a result, seek to establish good working relationships with the main UK Ada projects.

Overall within the Integration component of the strategy, work will be undertaken to select and encourage the use of existing relevant standards and to sponsor the introduction of, and conformance to, new standards so that

(i) the process of defining and producing PSEs is assisted

(ii) the use of PSEs is encouraged, since it will be expected that use will give rise to products that will conform to high quality and specification standards

(iii) external dependencies on components sourced from outside the UK can be managed more positively.

Innovation

The three key points to be made about innovation are that

(i) whilst the general directions in which innovation is needed are known, it would be premature now to try to pick winners and ignore rival approaches

(ii) research projects are often on too small a scale to provide an adequate testing ground for a new technique

(iii) the scale of UK research must be increased to compete with our international rivals and better co-ordination introduced.

Thus the programme will aim to back a number of promising approaches and test them out on life-size projects rather than attempt to evaluate them in terms of their apparent success in small scale use. This approach not only offers a better chance of selecting useful techniques, it also starts to bridge the "development gap" by bringing research results out into a development environment.

Some candidate areas clearly emerge when considering the requirement to build successively more powerful PSEs—

(i) formal, rigorous methods of specification of requirements and techniques to express designs and determine how far they meet their specifications

(ii) methods of structuring software or hardware system components for wide re-use; the nature of their interfaces to each other; the appropriate types of global designs to incorporate them; how to document them.

(iii) methods of measuring and predicting levels of productivity and quality, particularly reliability.

(iv) examination of the software production process in its industrial context so that the process can be better described and modelled and provide a sound basis for the construction of advanced management tools and techniques.

A vital general requirement within all three of the programmes listed above is the need to co-operate with, and incorporate aspects of, the other main Alvey strategy areas. In particular work will be directed towards achieving close involvement with CAD for VLSI, high resolution displays to support a high quality programmers interface and expert systems for programmers. Further editions of the strategy will develop more explicitly these inter-relationships between Software Engineering and VLSI, MMI and IKBS.

Overall the Software Engineering Programme will aim to ensure that a well founded balance is maintained between each of the three areas covering Exploitation, Integration and Innovation. This issue of balance will be the subject of regular reviews with the strategy advisory group.

An outline of the Software Engineering Programme's output and phasing is given as Appendix A, together with an outline budget estimate in Appendix B.

4. MANAGEMENT OF THE PROGRAMME — The Management of the Software Engineering Programme will follow the main recommendations of the Alvey Report. It will —

- be a directed programme. The Director Software Engineering will be responsible and accountable for the decisions made, within the structure of his responsibility to the Director of the Alvey Programme and the Steering Committee.
- be few in number. It will be staffed by a small number of skilled professionals with strengths and capabilities suited to the pursuit of the three main objectives of the Work Programme — exploitation, integration and innovation. These will be drawn from Industry, Government, SERC and Academia.
- as a result, aim to work through others. Specifically it will use, as far as possible, existing Government advisory mechanisms to assist in the shaping of the overall strategy; the achievement of better levels of co-ordination and the promotion of support for the strategy. This will be achieved through the use of the EARB Computing and Communications Committee as the main strategy advisory group. Furthermore it will seek to establish specialist panels to assist in the development of programmes for the specialist topic areas. These panels could also form the core of Alvey Software Engineering "special interest clubs".
- normally let contracts on a managing partner/partner basis with the managing partner responsible for the appointment of a co-ordinating manager for the project, responsible for its administration and execution. Guidance Notes for potential participants are in the course of preparation.
- sponsor collaboration. It will, on suitable occasions, be regarded as a part of the management process to suggest partners for projects. Final decisions on this will at all times, however, rest with the proposers themselves.
- recognise the importance of smaller companies in the software industry. In particular it will seek to evaluate the best way to help them and will take suitable action if smaller organisations' needs differ from their larger counterparts.

Overall the management aim will be to seek strong general support for the strategy, adherence to it as a key criteria for the selection of projects and the establishment of a sense of continuity within the programme.

5. RELATIONSHIP WITH ESPRIT — The main Alvey Report identified that the UK could not regard ESPRIT as a substitute for a strong UK programme; rather a UK programme would help the UK participate more effectively in the European one. The Alvey software engineering programme fully supports this view. It will seek at all times to identify how best to establish good levels of synergy between the two programmes and in particular the Alvey Programme will aim to establish criteria

that will allow it to determine where it will need to run totally parallel activities; where it would suggest an Alvey led programme; where it would be content to build upon ESPRIT and where it would be prepared to have ESPRIT handle a complete area of activity. In establishing these criteria the Alvey Directorate would seek wide consultation within the community. It would anticipate, however, that the following factors would play a significant part in the decision making process

- Criticality of topic area — can the UK leave it for others to do/does the UK have an important dependancy?
- Timeliness of proposed programmes
- Transferability of results
- Need for more than one programme in the area considered
- Weight of expertise in topic area

Areas which at this stage suggest that close co-operation could be mutually beneficial would be standards, distributed Unix, metrics, specification and verification methods.

6. JUSTIFICATION FOR THE PROGRAMME — The UK currently has an established and vigorous software sector in the UK with a mushrooming growth in the number of companies offering software products and services; significant overseas revenues and an academic community of world standing. In spite of this the UK continues to have an adverse balance of trade and its ability to maintain or, indeed, strengthen its position in this lucrative but intensely competitive market area will come under increasing pressure, not least as a result of the major programmes currently underway in its competitor countries.

An ability, therefore, to establish a capability of producing cost effective, high quality software is an essential prerequisite to the continuing health of the IT industry and, indeed, to the rest of UK industry which is already dependent on the provision of world class computer systems if it, in turn, is to maintain and develop its competitiveness. Consultation in all sectors of the community has identified that —

- the increasing dependence of business on economic, reliable and soundly designed computer systems
- the growing complexity of such systems
- the general failure of software producers to meet users' needs in terms of timeliness, cost and quality
- the specific programmes already in hand in America, Japan and France

all point to a critical need to move from the present ad-hoc "craft" practices of software production to a position which ensures that UK management turns increasingly to capital intensive methods of efficient software production and an engineered approach to reliability. It has been with this goal in mind that the programme proposed in this document has been devised.

In setting out to meet the above it is accepted that many important areas of interest have been omitted, eg database development, except for those aspects needed to establish distributed PSEs, and the production of specific applications such as CIM. In doing this the Alvey Programme has taken the view that it has finite resources and that these need to be focused in the sharpest manner on the areas agreed as of fundamental underlying importance. This being said, the Alvey Directorate will nevertheless aim to keep the areas of omission under regular review with a view to their possible future inclusion in the programme.

7. ACKNOWLEDGMENTS — The Alvey Directorate gratefully acknowledge the widespread co-operation and assistance of the many people from industry, academia and government who have helped formulate the Software Engineering Strategy.

APPENDIX A

OUTLINE OF SOFTWARE ENGINEERING PROGRAMME – PHASING AND OUTPUTS

EXPLOITATION	INTEGRATION	INNOVATION	YEAR
Annual programmes of workshops, seminars conferences and community building. Establish SE information service 1st Generation IPSE Demonstration Programme specified	1st Generation IPSE – Necessary Unix enhancement specified and work in hand Review and select candidate environments together with supporting tool sets.	Research projects commissioned to develop (i) An increasingly clear understanding of the full software process so that it is better described and modelled.	1
1st Generation IPSE Demonstration in "Software Production Centre(s)" Cost/benefit measurement work undertaken with progressive release of results.	1st Generation IPSE construction completed and established in EXPLOITATION phase 2nd Generation IPSE – – R&D for integrated framework including development of methodology	(ii) formal, rigorous methods of specification of requirements together with techniques to express designs and determine how far they meet their specifications	2
Quality Programme commenced "Quality Centre(s)". Incremental build of 1st Generation IPSE plus demonstration and measurement programmes	– R&D for user facility management tools programmer tools – R&D for systems support – Development of prototype and establishment in EXPLOITATION phase	(iii) methods of measuring and predicting levels of productivity and quality	3
Preparation for demonstration of 2nd Generation IPSE & associated Cost/benefit programme. Demonstration of 2nd Generation IPSE in "Software Production Centre(s)"	3rd Generation IPSE– – R&D for architecture – Feasibility reviews – Basic Specification	(iv) methods of structuring components for wide re-use	4
Cost/benefit Measurement work undertaken with progressive release of results.	AI assisted tools for management and programmer support developed & integrated in 2nd Generation IPSE.	Each of these streams of work will commence in year 1 and will feed results and techniques into the INTEGRATION phase.	5

APPENDIX B

ALVEY SOFTWARE ENGINEERING – OUTLINE BUDGET

STRATEGY COMPONENT	TOTAL SPEND £(m)	%
EXPLOITATION	19·7	30
INTEGRATION	28·3	44
INNOVATION	17·0	26
TOTAL	65·0	100
EXPECTED GOVERNMENT CONTRIBUTION	38·3	

The above levels of expenditure are for the five years commencing 1984/5 and running through to 1988/9. They are at 1983 prices and represent current outline estimates which will be progressively refined in the light of the emerging detailed programmes of work.