II
DESIGN AND DEVELOPMENT

II DESIGN AND DEVELOPMENT OF SYSTEMS FOR MUSEUMS AND GALLERIES

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This paper is aimed at identifying and discussing some of the critical emerging issues in the design and development of systems for museums and galleries. The focus of attention is primarily directed at museums and gallery people who are not information technology specialists. The intention is neither to present detailed technical information nor even in-depth case studies since the latter is carried out extensively elsewhere in the programme and the former is in a state of rapid flux with many competing approaches. The intention is however to point out some key issues and new directions and set the scene for subsequent papers.

The paper is organised in three main parts as follows:

- the need for new paradigms for systems design and development in general and for museums and galleries in particular
- principal methods, trends and changes in systems engineering design and development processes.
- specific issues affecting design and development and concluding comments.

It is worth emphasising here that design and development in the field of systems - and especially the software component - is one of the most fast-changing and thus risky types of endeavour. Many differing approaches are being proposed and used but despite the confusion some organisations are able to produce outstanding results.

The need for a new paradigm for systems design & development - especially for Museums and Galleries

There are a number of pressures leading to the need for a new paradigm in this field including in particular:

- rising 'user power'
- increasing importance of 'content software' versus computer software
- the switch from one main technology (Computing) firstly to two: Computing and Video (& Multimedia) and now to three with the increasing role of Telecommunication
- increasing speed of technological change
- international collaborative efforts.

We shall discuss each of these in turn and the corresponding implications on the design and development process.

Rising 'user power'

It is very noticeable that 'user' involvement in multimedia systems is becoming increasingly a matter of real importance and not just 'lip service' by systems designers and developers.

In the context of museums the term 'user' means the curatorial and other staff using the computers in a general sense including their application to help inform, educate and entertain the museum visitors.

In traditional computer systems development the 'user' role was generally just to contribute to defining the 'user requirements' and then to participate in 'user testing' and 'user training' and installation' etc., apart from a senior level 'user management' role mainly concerned with issues such as schedule and overall strategy

This has changed due to a variety of reasons including:

- more 'users' want - and are able - to contribute effectively
- designers and developers wish increasingly to get 'user' involvement
- it can help to produce outstanding results - especially with the 'lead user' concept such as the role taken by the National Gallery staff in the VASARI Project.

Well documented empirical results are reinforcing the vital role of the 'user' in innovation and in general support, as identified in particular by Erik von Hippel of MIT. Greater curatorial 'user power' or involvement inevitably impacts upon the design and development processes which cannot then be conducted in an 'ivory tower'.

Increasing importance of 'content' versus computer software

In certain types of computer systems work it is the content not the hardware nor the software which constitutes the biggest single cost component. In the Geographic Information Systems area for example, figures for cost as high as 70% of the total cost of project are sometimes quoted. This may well be relevant for some types of multimedia system as well, especially for museum and gallery multimedia systems. To date the science and art areas have been the leading ones in the museums and galleries field in the application of multimedia Social History museums as well as Military History ones e.g. the Imperial War Museum, are also involved in pioneering work which necessarily involves significant curatorial work to select and prepare the materials as well as collaborating in the actual design of the system.

The National Museums of Scotland is a case in point, their work spanning low-cost multimedia systems in the Discovery Room (Bryden, 1993) to a major system, MOSAICS (Clarke, 1993) which is due to go 'live' in 1998 as an integral part of the new Museum of Scotland. In both these cases, the curatorial role in the system design including image selection and text preparation is significant. The Discovery Room is notable for its use of objects and 'multimedia' systems in a symbiotic set of instructive and entertaining exhibits on topics as diverse as whisky and clothes. Indeed, this is perhaps one of the few 'really multimedia' systems. MOSAICS is planned to be a major computer system which will form an integral part of the museum as a whole and which, without challenging the

supremacy of the object-based experience of the visitor, should enhance the pleasure and value of the visit.

One 'main technology' to three main technologies

Up to the mid-1980s, the computing industry was imbued with what may be seen with hindsight as dangerous isolationism and overconfidence. IBM, for example, appeared unchallengeable by virtue of - inter alia - its superior management capabilities. Although some visionaries and leaders foresaw the convergence of computers, television/video and telecomms worlds, this did not really take off until the beginning of the 1990s.

The impact of these developments is not only to generate even more exciting opportunities for the late 90s and next century in general but also to add to the complexity of the design and development process. One key aspect is that these differing technologies bring with them distinctly different 'cultures' as regards design and development e.g. the software development world is a very different one from that of television video production and even within these areas such as software there are many differing 'sub-cultures' and multi-disciplinary multimedia teams are required as discussed later in the paper.

Increasing speed of technological change

This is an oft-quoted aspect of modern technology and is generally made with the accompanying observation that product cycles are now often in months rather than in years. Certainly it is clear that the current cornucopia of different offerings (CD-I, CD-ROM etc. in the multimedia field for example) creates considerable confusion and difficulties as well as often leading to delays in purchasing decisions and systems delivery.

The impact of increasingly rapid obsolescence of most products is to make design and development an increasingly risky exercise except in the case that 'open systems' or 'upwards compatibility' or other approaches to protect or 'future proof' the investment can be used.

International collaborative efforts

The world is increasingly becoming a 'global village'. The museum field is one of particularly close international collaboration in general and this is becoming the case also in the area of computer applications.

In the late 1980s, international collaboration in Europe received a special impetus due to financial subsidies from the European Community and this has increased in the early 1990s so that currently there are now numerous European collaborative projects often bearing mysterious acronyms, including:

VASARI	MARC BRANCUSI
NARCISSE	MUSAFASHIONBASE
EMN	RAMA THE SACRED WAY

These projects are particularly challenging in terms of design and development in that by fiat this function is generally carried out in at least two different European countries. This inevitably leads to extra organisational and management challenges in the design and development process. The remarkable result is that in many cases - although of course not

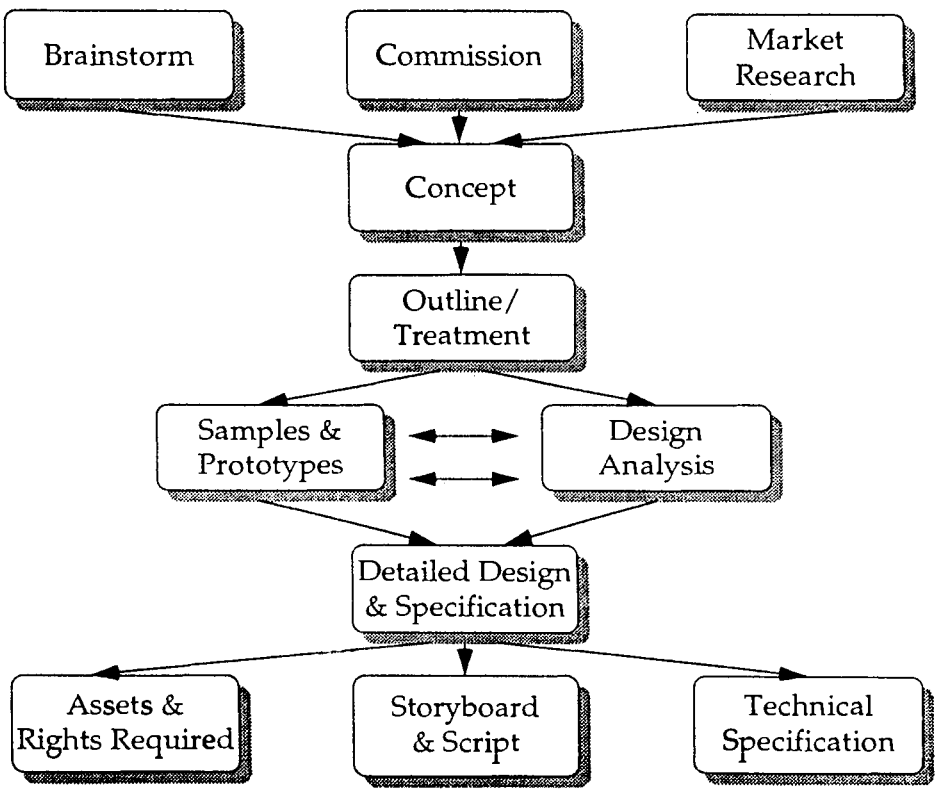
all - the results are justifying the inevitable difficulties and new modi operandi (for Europe) are emerging such as cross-continental design and development project teams and organisational relationships which sometimes correspond to the demanding exigencies of the fast-moving 'liberation management' concepts currently being embraced by some North Americans top management gurus (Peters, 1993). Such R & D projects are being followed by similar commercial undertakings which would have been unthinkable in the 1980s. For example, the national museum in country X purchasing bespoke computer systems from a supplier in country Y at the opposite end of Europe.

The combined effect of these and other important new factors such as the impact of rapidly falling product costs make design and development a constantly varying maze and one for which the most common systems development approaches - evolved during the period when mainframes set the fashion are becoming ill-suited. We believe that new paradigms for systems development are needed to meet the complex situations of the 1990s which are impacting not only museums but all application areas. However, in order to be able to argue this case we should first review some current multimedia design and development approaches, classic computer systems design and development approaches as well as new trends.

Principal methods, trends and changes in multimedia and general systems engineering design and development

Multimedia system design is still at an early stage in its history. One basic approach is described in the Philips IMS CD-I Design Handbook consisting of the following stages and illustrated in Fig.1.

Fig. 1 Stages of design: CD-I



Source: CD-i Design Handbook, Philips

- Concept & Treatment
- Design Analysis
- Detailed Design
- Production

Philips acknowledged in their book that the design methodologies are in a state of rapid development. It appears that the television/video industry, more than the computer industry, have been the major influence. A revealing quote from Philips (92) is:

> 'Most CD-I designers agree that, while it might be tempting to exclude programmers from early stages of design development, it's a good idea to have someone around who thoroughly understands the technical aspects of CD-I and can quickly spot any potential pitfalls before effort has been wasted on designing something that can never work'.

The work plan for the CD-ROM Development and Production of a current European project includes the following major steps:

- Specification & prototyping
- Storyboard
- Capturing/conversion text, images, audio, video
- Graphics
- Programming
- Processing
- System integration
- Documentation
- Quality control & testing
- Premastering
- Mastering
- Packaging

In both cases despite emphasis on prototyping a vestigial linear philosophy is clear. This was also the initial path in the computer industry and it is instructing to see how computer industry practice has evolved toward a more direct formulation of the iterative nature of the overall process as indeed have more multimedia system developers as described later.

Computer systems in general and software in particular is regarded by many - both inside and outside the profession (if one may yet use this term!) as one of the most complex, challenging and difficult of society's undertakings. It has therefore also proved to be one of the most risk and accident-prone e.g.

- a space-shot aborted because of a missing comma in the code
- mis-functioning of medical equipment due to software errors leading to human injury and death
- financial failure/disruption of companies due to software difficulties both at operational and development phases.

All of these problems and many more are well documented in the computer literature and the computer software 'Quality Crisis' has resulted.

Nonetheless, due to the promise(s) and potential of computer systems as shown by a large number of successes, software has grown to become an increasingly important element in computer systems and also in economy and society as a whole. A major effort has been

made by many computer systems and software specialists to make their work more manageable and 'transparent' - including the customer! (Of course, many still prefer to hide behind the mystique). The leading Japanese have made particularly noteworthy efforts in these directions.

We now examine in some depth the computer systems situation which in view of its similarity (and growing convergence) with multimedia systems and somewhat longer history may offer some pointers for the future development of museum multimedia systems:

- the two main 'classical' models of software design and development
- key trends and significant changes likely to occur in the 1990s in software design and development practices.

The two main classical models

Software and systems design and development are generally viewed as a 'life-cycle': from birth to death. The two main models used are:

- the Waterfall method
- the 'V-model'

The Waterfall method is shown in Fig.2 which in discrete block form sets out the main steps in the software design and development process:

The Waterfall model is simple and provides a clear road-map for a project but in particular is crucially dependent upon a sound requirements description. Without that - as has been discovered and re-discovered - in many a bitter experience - including in the museum field. Other weaknesses include a lack of sufficient attention to the inevitable feedback loops and iteration in almost all projects and also the lingering impression with some observers that the Waterfall visual analogy is all too true!

The V-Model, as shown in Fig.3, addresses the issue of feedback loops and in particular provides a good framework for relating activities in the upward area of the V to those corresponding parts of the downward arm which are often the source of many of the problems plaguing the former. The main components of the V-Model are essentially similar to those in the Waterfall Model. Weaknesses include - in practice - the dependency on good requirements specification as in the Waterfall Model and the frequent need for interactive processes not essentially linear ones.

Key trends and changes

There are continuing efforts to promulgate best practice in the 'software & systems' engineering fields. This is being carried out in many forms and we describe one as an indicator: the efforts of the world's premier standards organisation ISO/IEC through their Joint Technology Committee 1 and the corresponding sub-committee on software engineering. There is, for example, currently a standards development project led by the Americans but involving members from all round the world to develop a software life cycle standard in order to help developers internationally be in accordance with international best practice.

But the Software and Systems model design and development is not necessarily the best approach for museum systems. There are other alternatives such as:

Fig. 2 Evolution in computer systems development

a) The 'Waterfall' Model

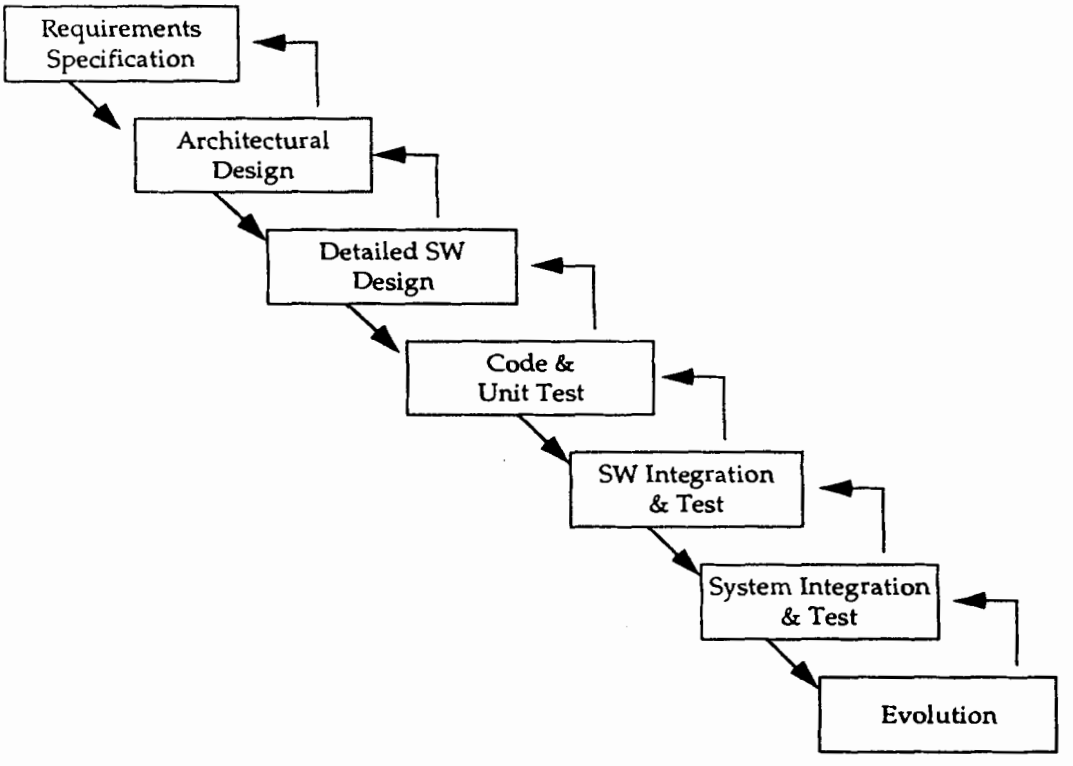
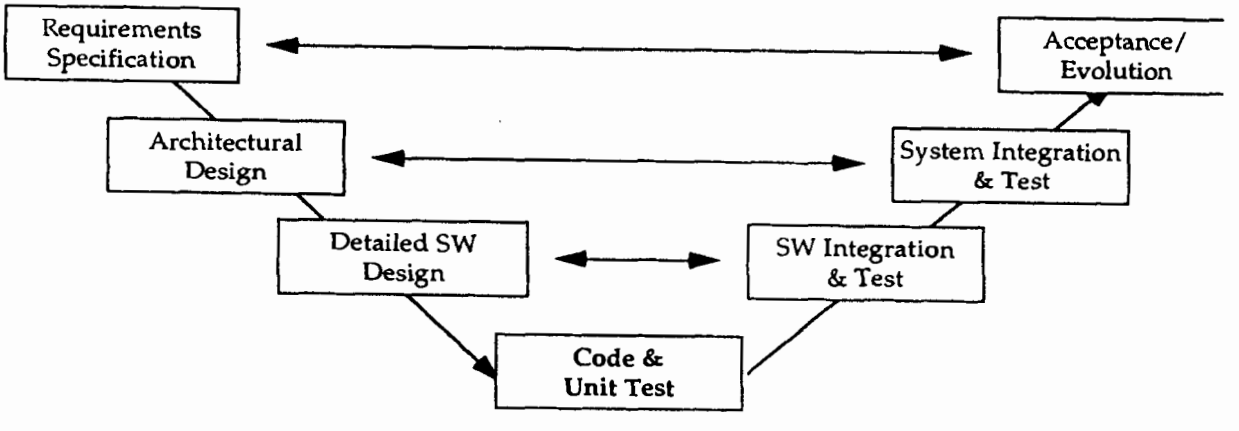


Fig. 3 b) The 'V' Model



- The Television Programme production model in which a temporary team, are assembled for a specific ' project ' using the equipment and other resources of a TV studio. The team consists of a small core group - perhaps no more than a handful which is then supplemented by a network of (sub) contractors.
- The Book publishing approach in which the leading role is that of the editor.

For museum systems the question is still an open one. The supplier industry itself is 'learning by doing' and good management and organisation of the design and development process are cited by a number of the top multimedia systems suppliers as a key element in their competitive edge rather than their technological capability.

A particular characteristic of museum systems compared with Television or Publishing approaches regarding the importance of the collections and the range of associated copyright problems.

Another significant trend in the movement towards 'Quality Management Systems' as set out in the ISO 9000 series of standards and the recent ISO 9000-3. The ISO 9000 series of International Quality Standards is now being adapted world-wide in an increasing range of industries including now also multimedia systems. ISO 9001, which focuses on Design and Development includes 20 keys topics, ranging from Quality Policy to the use of statistics and is a prime instrument for the dissemination of quality management systems. It is however, influenced by manufacturing industry and in response the ISO 9000-3 standard was prepared which is for the application of ISO 9001 to software.

Further indicators of the efforts in the software community for continuing quality improvement is the 'Process Maturity' approaches from the Software Engineering Institute of Pittsburgh, supported by the US Department of Defence. This is based as a simple but elegant and practical model of the 'maturity' of a software engineering process ranging from Level ONE: 'CHAOS' to Level FIVE: ' OPTIMISING ' (ISO 9001 corresponds approximately to Level THREE) This model has proved in practice to be a major help to improve the 'maturity' of their process development and therefore also of their products. The previously recognised need for such improvement was confirmed by late 1980's studies of leading US software development organisations which showed that some four out of five were at Level ONE i.e. ' CHAOTIC ' class. In the multimedia supply sector the same issues arise! Fig.4 shows the SEI model.

Finally, there is the SPIRAL approach first proposed by Barry Boehm and illustrated in principle in Fig.5 in a simple form as employed in the VASARI project which was a complex systems development project (Saunders, 1992). This approach when used in a detailed operational way provides a more controlled framework for the inevitable interactivity. Some Multimedia system developers are using approaches which are essentially variations of this process .

A final comment on the industry structure of multimedia system suppliers is accordingly relevant since this is a key factor effecting design and development maturity and, therefore, (so the theory goes!) quality. The industry is currently characterised by a high number of small companies, as is frequently the case in new technologies and markets. The 'shake out' process is already under way and a relatively small number of large well financed organisations are increasing their role in the market e.g.

- MICROSOFT
- SIDAC

Such organisations are far more likely to use a more systematic approach to systems design and development than a small creative team, although both approaches can lead to

Fig. 4 The SEI software maturity model

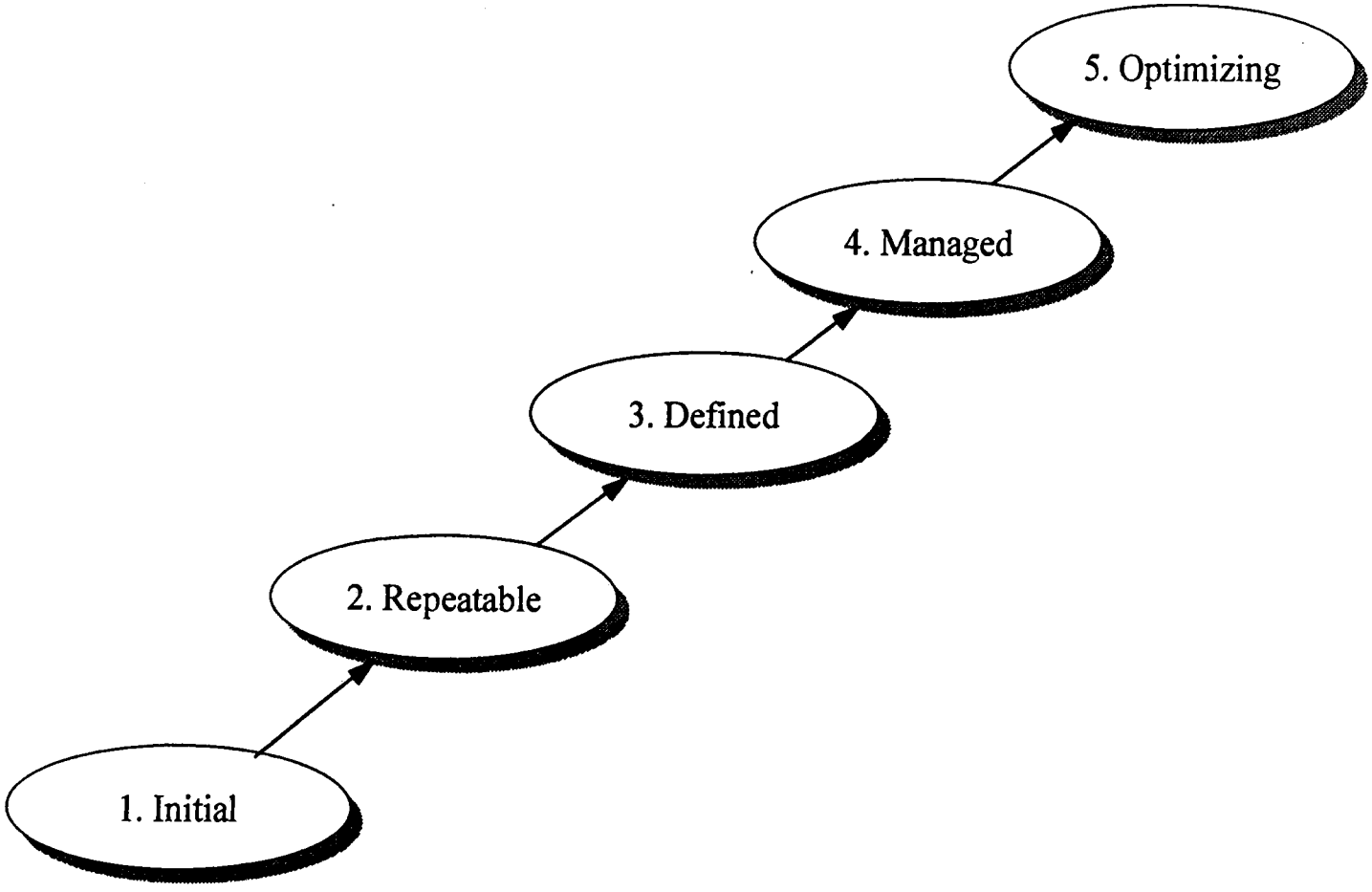
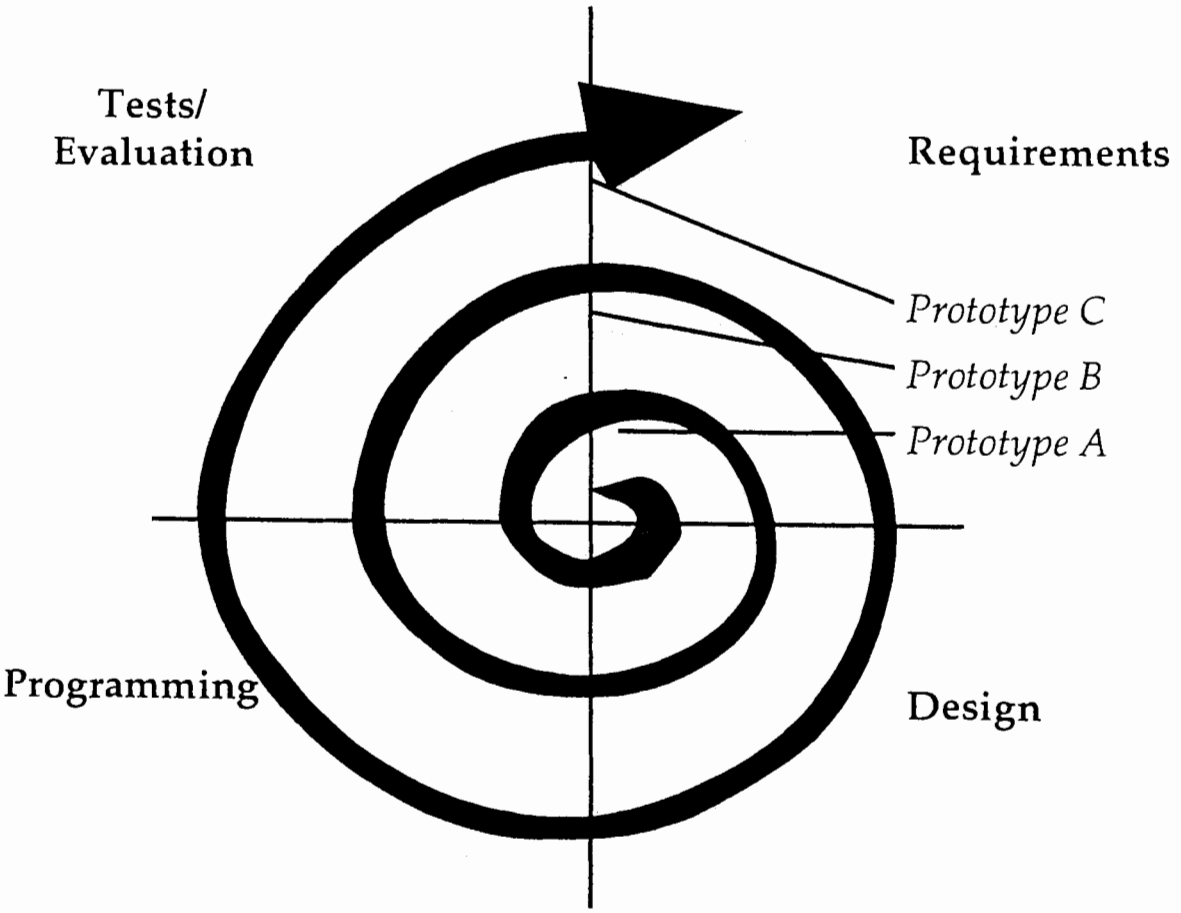


Fig. 5 A simple prototyping model (following Boehm)



Source: VASARI Project

outstanding results. There are many other factors such as the key designer and the role of the customer. However there are ' small ' companies of under 30 staff which such systematic approaches including for example Media Projects of the UK which is aiming for the ISO 9001 (BS 5750) award.

Specific issues and concluding comments

In this final section we identify some specific issues which impact particularly on design and development. There are of course many others !

The audience

Knowing the audience/market end user is priority one, two and three. This includes answering the following questions:

- Who are they? (in general terms e.g. children and/or adults, individuals, pairs or groups)
- What are their key characteristics? (e.g. any disabilities, language abilities, computer ability, subject knowledge)
- What will they like to obtain from the system? (not necessarily what the designer would like them to receive !!) Do they in fact prefer to interact?
- What will be the viewing environment of the audience?
- How much time will they typically want to spend interacting? (assuming the system is available and 'attractive')
- Will they be 'repeat' users?
- What system features are they likely to find particularly attractive and effective ?
- What are they willing to pay? (generally assumed to be zero for Museum Visitor System)

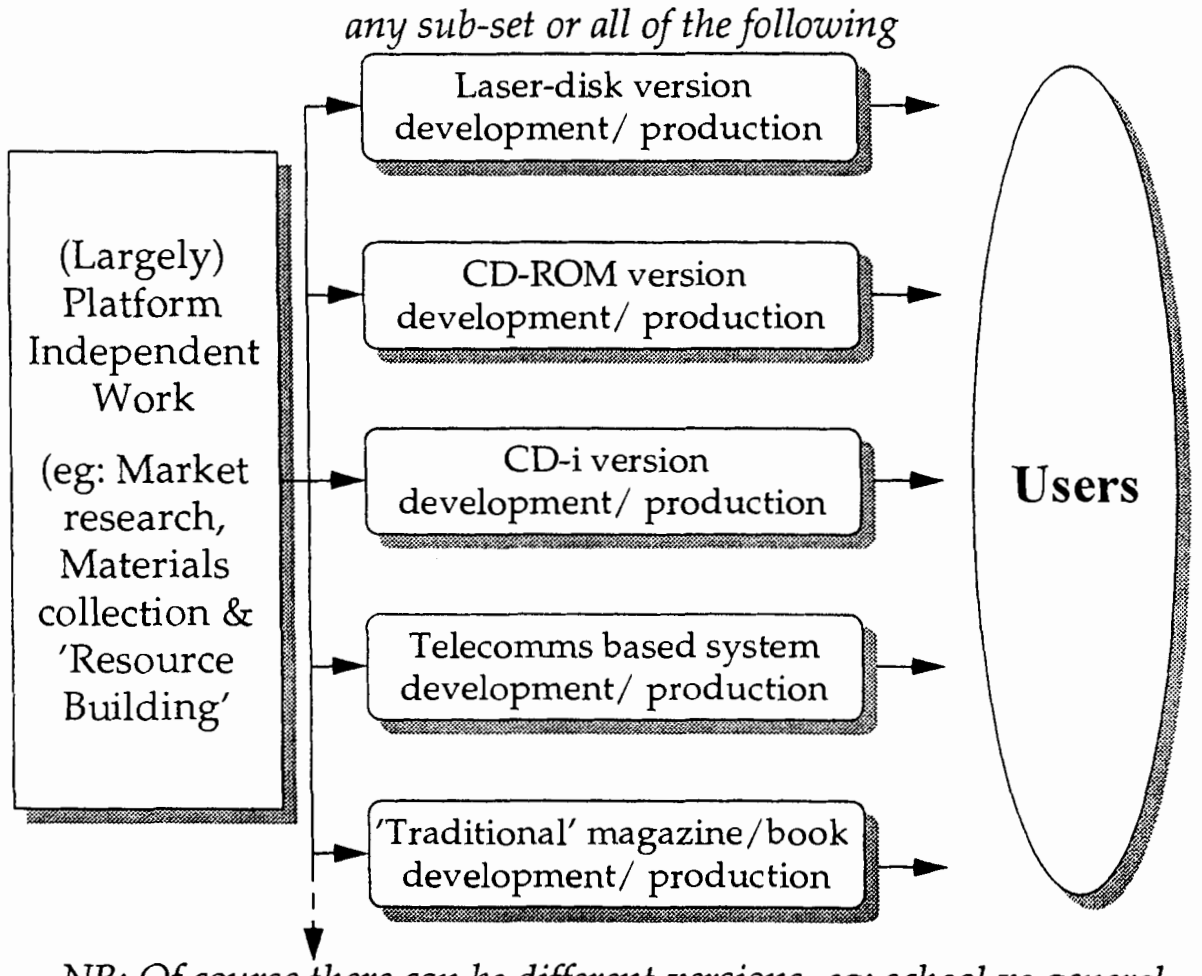
There is now a substantial scientific effort engaged on 'user modelling' or profiling as well in as providing a range of methodologies for 'capturing' user requirements. This reflects the fact that the problems/failure of many systems projects (not just in museums) has been due to insufficient understanding of the users and their requirements. The implication for design and development is that this is not only a vital preceding key but an on-going task, as made explicit for example in the SPIRAL model.

The team

A multi-disciplinary team is needed with skills desirable including:

- Content specialists (researchers and writers)
- Graphic designers
- 'User' representatives e.g. Curators, Educators
- Human Factors Specialists
- Software and other technical staff
- Photographers, sound and video staff for new materials
- Project management staff
- 'Creative Directors'
- Marketing people for 'products'

Fig. 6 The multi-platform approach



Furthermore for telecomms based systems additional specialists are necessary. The resulting number of staff would appear to be undesirable on financial grounds for any but the largest project. However, successful projects are finding ways and means to get these skills.

The choice of platform: 'one' or 'multiplatform'

The question of which platform (hardware plus operating systems and other 'building blocks' software') to elect is a crucial decision in any systems project. A current trend to avoid is a single machine decision. 'Multi-platform' development is being regarded as a sensible way of minimising the risk and maximising the potential return from a CD-Publishing project due to the likelihood of technological change involved over the development time of the project. 'Future-proofing' is not easy due in particular to both rapidly evolving *de facto* standards and slowing evolving formally agreed international standards. Therefore since a large part of the development costs (e.g. materials and market research) are completely or in part independent of the actual choice of medium a number of system projects are considering multimedia systems on, for example, CD-ROM as well as CD-I or laser disc. It is also possible to consider on-line access to establish telecomms based systems. This is shown in Fig.6

It is possible that some ideas from this type of approach may be helpful in museum systems development. At least one UK company is already employing a variant of this approach.

Finance

A major consideration in the choice of system design methodology is the size and cost of the project. The production of a significant system/CD publication can easily be in the range of 250 - 500,000 ECU/dollars, but this is already beginning to drop in accordance with the 'experience curve' phenomen.

A large system including millions of images can be in the millions of ECU/dollars in total cost. However, a small system can be well under 100,000 ECU/dollars and adequate systems for small museums can be as low as a few thousand dollars (e.g. a basic Apple configuration plus many hours (uncosted) curatorial effort!

Some concluding comments

- Museum multimedia systems design and development is in the process of 'learning by doing' with (especially) the leaders engaged in a steep learning curve. Some museums, in this regard, are changing from being technology laggards to leadership positions and models in technology application and indeed some are already beginning to influence the technology development especially in Europe thanks to EC Funded projects.
- At the nexus of the Computing and Video world and now increasingly also with the Telecomms world there can be a creative interplay of the disciplines and a need for special approaches reflecting the particular importance of the visual collections.
- The End-users - both general public and museum professionals - are increasingly demanding and are the final arbiters of quality.