TIME FACTORS IN REALISING IT BENEFITS IN CONSTRUCTION

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ABSTRACT: Achieving benefits from the introduction of information technology in building design and construction is dependent upon three time factors: the time taken to get the systems into full operation, the time taken to reengineer business processes, and the phases of the development cycles of both IT and construction at the time of introducing the systems. This paper uses examples from the Danish, United Kingdom and United States construction industries to show changes in productivity and their cycles of activity. Examples are given of time factors affecting IT projects, and three different durations for IT projects are identified. The paper concludes with a proposal for when IT development projects should be undertaken in relation to their length and the phase of the construction development cycle.

KEYWORDS: information technology, productivity, construction cycles, benefits

1. INTRODUCTION

Information technology is such a fast moving influence on all industries that it often drives radical change in business processes before the need has been fully assessed. In construction, which is relatively slow to change, there is often a mismatch between the time when technology suggests change, the business needs of a company, and fluctuations in workload. Where studies are made of the benefits a new technology would bring, they often fail to take account of all the different ways in which time can affect the result. There are many stories of major IT projects that are obsolete before they are fully developed. These, and the fact that the productivity of some industries cannot be shown to have increased since IT systems have become widespread, have lead to use of the term 'The productivity paradox' [1].

The construction industry tends not to carry out large scale IT development projects. It is mainly a user of packaged software, although some of this requires changes in business processes to obtain full benefits but, since it involves changes in people and organisation, it can often be a longer process than is estimated. Productivity studies of construction in various countries over the last 30 years [9,10] have shown little increase in value of output divided by total work time, while other industries have had increases of 80-150%. These changes form a complex picture and, while some developments should have improved productivity, others, such as increasing complexity in legislation and building technology, have reduced it.

The cyclical nature of construction output is affected by the economy of the country and whether it responds to planned objectives or to market forces. Denmark and Saudi Arabia [4,6] represent more planned economies and show targets being set and reflected in volumes of output, while the UK and US show regular fluctuations caused by political change and capital investment reflecting the state of the economy in an exaggerated way.

IT development projects should ideally be driven by the needs of the users and business process change should be planned at the same time. IT developments will always affect this and cannot be ignored. The level of demand expected for construction, when any new system is likely to be fully implemented, should also be considered.

2. TIME FACTORS IN IT BENEFITS

A survey of Danish firms in construction on whether, and how, they estimated the benefits expected from new IT systems [2], showed that few firms did this except in a subjective manner. Methods used to show when benefits would start to be obtained are often very simplistic like the assumption of half the eventual level of productivity being obtained from CAD for the first year [3]. In fact for most systems which involve a lengthy learning curve, and which affect an organisation's business processes, the productivity levels are probably growing over most of the life of a system, and then its replacement has to be planned to take advantage of improved technology.

Three time elements affecting the realisation of IT benefits can be identified:

1. The time for acquiring the necessary systems, installing them and training users.
2. The time needed to load data, reorganise business processes and integrate systems
3. The relationship of these with cycles of IT development and construction workload

2.1 System acquisition

This is the first stage of the process in which needs are assessed, a system specified, its hardware, software, data and communications components acquired, and staff trained and familiarised with the system. The timescale for the whole process is quite variable and three types are identified here. If it is a complex system specific to a single organisation, it may require development and testing of innovative software, which can be a lengthy process. Ten years might be needed to obtain benefits from what could be called a 'Long term system'.

Other systems may be built within flexible software tools such as CASE, or may require setting up data specific to the user company. Examples of these are company management databases and CAD systems in which standard details or libraries of objects may have to be loaded to obtain productivity gains. Such systems might take 2 years to break even and need replacing after 5 years, and could be called 'Medium term systems'.

Most systems used in construction are standard applications working on the Windows PC platform that is almost universal currently [4]. These might only take a few minutes to set up although most users would take months to become expert. The time scale for reaching break even is up to one year for what could be called 'Short term systems'.

2.2 Integration and reengineering

Some of the earlier applications of IT in construction imitated manual processes and required relatively little change in business organisation. Word processing, for example, produced similar output and was easy to integrate. The productivity of such applications is not in doubt. Other applications were used in a similar way, and CAD used for drawing production is an example of this. However it has always been clear that CAD could radically change the process of representing and exchanging project information if more comprehensive models were built and direct access was provided for all those inputting or extracting data. This is now starting to take place but it has taken many years for this opportunity to be grasped, and there is still a majority of CAD users who have not been able to make the changes necessary in their projects or even in their own offices.

If the business process change required is just within one organisation it may be relatively simple. However most construction projects require collaboration between many firms and, unless these have a continuing relationship, as in partnering, the chances of all those working on one project having reengineered their processes in a similar way are very small. The time factors in process change are very much longer than those for system acquisition, and process change should start at, or before, the system specification stage in order that the organisation is ready when systems reach full productivity.

2.3 Time cycles in IT and construction

The rapid advances in IT often pressurise firms into buying systems just to find out what they can do. This can be a mistake since a successor system may be available before the necessary process change has been made. IT systems have periods of relative stability, for example the current dominance of Windows allows much integration of software. If a system is acquired at the beginning of such a stable period, it is likely to have a longer useful life before obsolescence sets in, and there is then time for business process reengineering.

To plan a system acquisition on predictions of when superseding technology will arrive is very difficult. The current significance of the Internet was not anticipated five years ago although it had existed for many years beforehand. The case study from a Danish partnering project that is given later [5], shows how one of four housing consortia was quick to adopt groupware for coordination in 1995 and has since had to change its software twice. The Internet is likely to be the major factor in IT over the next few years, but who can say what the next technology to cause major process change will be.

Time cycles in construction are a little more predictable in that certain types of economy show regular fluctuations, often linked to political events such as elections. Few governments resist the temptation to boost the economy before they are due to go for re-election. What is difficult to foresee is the size of the boom or bust that happens. The major recession of 1990 was not unexpected and, even though it reduced workload in the UK by only about 12%, the effect was devastating.

Planned economies should be easier to predict but even these are affected by world events in an increasingly global economy. Saudi Arabia used its oil revenues to build up its infrastructure to a peak of 700,000 billion riyals in 1980-5 [6]. Since then it has declined steadily since most building needs have been met. Denmark had a similar target for provision of housing and this built up to a peak of 55,000 per year in 1973. It also fell after achieving this goal and, since 1980, has fluctuated in a more market driven economy. As a small country Denmark’s construction workload reflects major projects, such as the bridges between its islands and over to Sweden that are now complete, and hence workload is falling.

3. PRODUCTIVITY CHANGE

The productivity paradox was first identified by Morgan Stanley in its economics newsletter in 1987 [7]. Their chief economist, Steven Roach, tried to explain why productivity growth had slowed since 1973, while the amount of computing power had grown substantially. He concluded that computerisation had little effect on economic performance, particularly where there were large numbers of information workers. Paul Strassman in 'The squandered computer' [8] could find no relationship between investment in IT and industry productivity. This situation must have changed by now in businesses such as insurance and banking where a simple division of value of business by numbers of workers shows increased productivity.

In construction this is not so simple since enterprises are not as large and depend more upon integration of their information with that of a changing array of project collaborators. While IT must have had some impact on productivity in the last ten years, during which its use has become widespread, there have been many others changes taking place in legislation, construction complexity, salary levels, competitiveness, etc. It is difficult to separate these effects, some of which increase productivity while others reduce it. Other industries have made great advances in productivity in the last 30 years as in the graph produced by Paul Teicholz from the US Government Statistics [9] (Fig 1). This shows all other non-farm industries as having increased productivity by 80% while construction has declined.

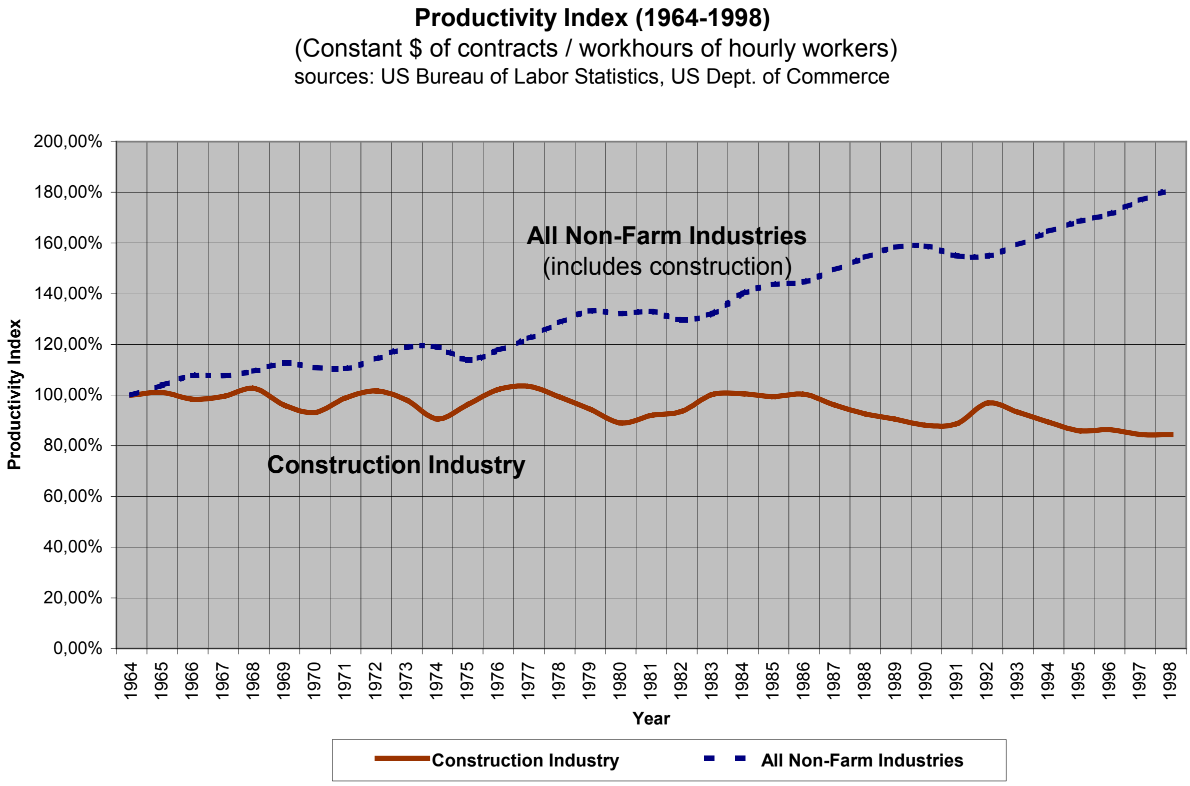

Fig 1. US construction productivity compared with other industries. Paul Teicholz.

In Denmark a similar graph was presented in the report 'Building in the 21st Century' [10]. This showed that productivity in construction had remained the same since 1966 while other industries had increased theirs by 130%. The UK construction output based on DETR statistics [11] since 1980 shows similar fluctuations to the US with some peaks, such as that in 1990, much larger than others.

One major factor in these productivity figures is the number of people employed in construction. The major recession of the early 1990s resulted in greatly reduced employment in the UK but less change in the more planned economy of Denmark. This difference is reflected in a graph of the relative change in productivities in construction of major industrialised nations based on statistics from the OECD [11] to which some data has been added for Denmark (Fig 2). This is only relative and it would need to be compared with changes in employment and industry output over the same period to indicate the actual value of these changes. The graph shows UK productivity climbing from the common base of 1990 while that in Denmark has fluctuated. To what extent has IT affected these changes in productivity and have the benefits of rapid growth in IT use since the 1980s yet been reflected in the productivity figures? The following case studies give examples of some of the types of savings being achieved.

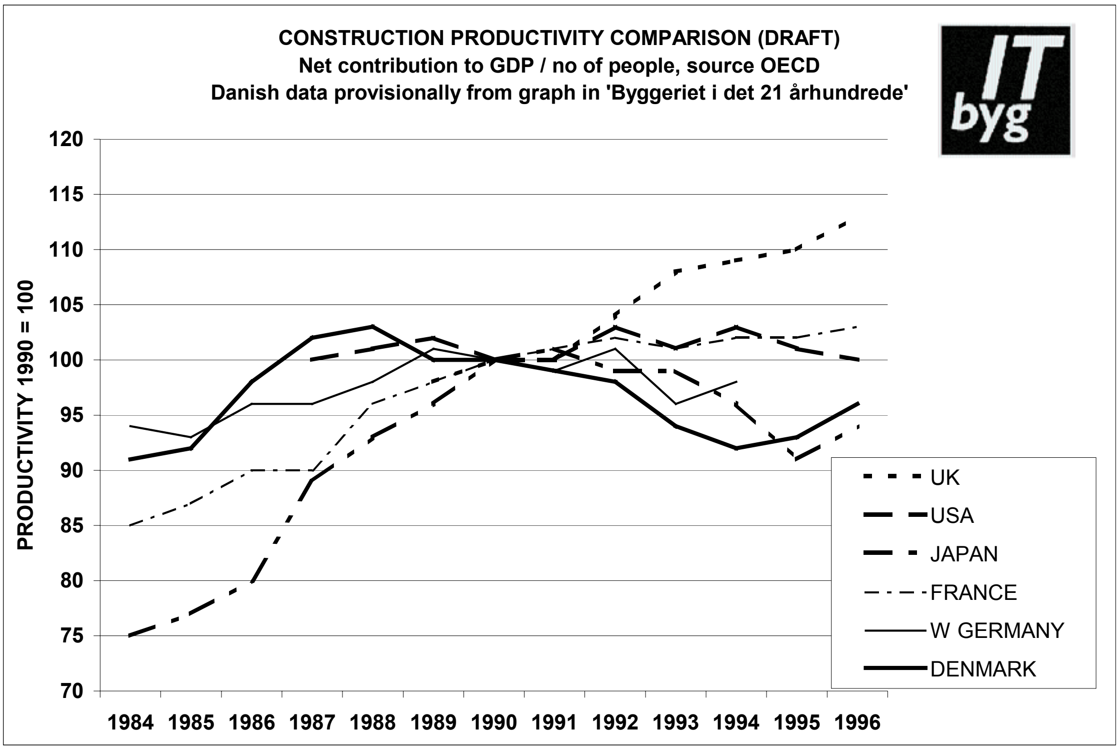

Fig 2. Changes in construction productivity compared with 1990. OECD & ATV.

4. CASE STUDIES

4.1 Case study - Danish housing by the Product & Process Development Consortium

This is one of four consortia of architects, engineers and contractors, which have been developing new methods of cooperation and construction on a series of housing association projects since 1995. A development project supported by the Danish government encouraged the consortia to develop innovative methods in the areas of: partnering, industrialisation, improved logistics, flexible building systems, integrated IT, intelligent houses and low energy, environmentally friendly, buildings. The PPU consortium includes: Arkitektgruppen Aarhus, Ramboll - consulting engineers, and Hojgaard & Schultz, contractors.

The IT byg group at the Technical University of Denmark is monitoring the use of IT and, particularly, the forms of communications used. While using a fairly traditional form of construction, PPU established a means of exchanging information through Lotus Notes initially and, more recently, through a Project Web. Information is normally exchanged through attached files although there were limitations in exchanging CAD files initially, and translations had to be made between the different systems used by the architects and the engineers.

The original target for project cost saving as a result of these innovations was 20%. The maximum that has been achieved so far is 5%. While other consortia have set up radically new methods of procurement or have standardised forms of construction, PPU's savings were due to come mainly from improved logistics and the use of IT. What they have achieved by standardising procedures and information systems is a reduction of defects, with none occurring on their fourth project, which was delivered a month early.

The investment in setting up their consortium and developing these innovations was about $2 million, with almost half from government. The benefits have taken longer to arrive than was expected. The original development project was 5 years, since extended to 7. There has not been the continuity in the housing projects that was expected and full understanding between the partners has taken time to achieve. However they were the first of the four consortia to develop their IT systems but, as a result, they have had to change their software three times.

Fig 3. One of the consortium members at a housing project by the PPU consortium

Even with partnering over a series of similar projects, it has taken time for people to adopt new methods of working. Their project manual was a valuable aid to cooperation and they used the Danish guidelines for structuring CAD data, but they had to establish trust between the partners. Now they are using the web for access to common data and have more continuity of projects, they should be able to increase the 5% saving on, typically, $7 million projects, that is $350,000. This about one sixth of the investment in development for eight projects, but they intend to continue the consortium after the end of the PPB development, and all partners will have gained from the experience. Although the programs used for CAD and logistics could be classed as short and medium term, some have had to be changed several times, and integration of people should really be classed as a long term project which may not break even for 10 years.

The next such development project in Denmark, Projekt Hus, is setting up teams to establish new methods for buildings of other types, and includes the client - vital for true partnering. Fortunately it has a longer period of 10 years to show benefits.

4.2 Case study - Implementation of an Electronic Document Management System

This case study has focussed on the costs and benefits of implementing an EDMS system called OpenDoc (an off-the-shelf IT system) in a building project in the UK. The company implementing the IT system is Costain which is a major contractor company in the UK. The building project was a large shopping center in Uxbridge called "The Chimes" and the client was Capital Shopping Centres (CSC). A joint venture between Costain and Skanska has been chosen by CSC to complete the building project. The length of the work period on the building site is estimated at 118 weeks with completion in February 2001. The building project is, in most aspects, a traditional project. This case study began midway through the building project after the implementation of the EDMS system.

Several case studies are being conducted by two Ph.D. students, Nick Bunyan from the University of Salford and Jan Andresen from the Technical University of Denmark. The focus of the case studies is the measurement of costs and benefits of IT investment in the construction industry. A framework called "Measuring the benefits of IT innovation" was developed by Construct IT at Salford University and is being used.

The IT investment in this case study is an EDMS system implemented on a trial basis in one of Costain's building projects. This replaces the existing data communication procedures used in Costain with a digital document management system. The IT system enables electronic management of documents like CAD drawings, meeting notes and others. The IT investment was initiated and justified mainly for strategic considerations. Evaluation using quantifiable measures was therefore not considered necessary. This is supported by the fact that the IT investment was seen as a trial on a single building project to identify the potential benefits.

The resources needed to implement the IT investment were not estimated as high and the directly identifiable benefits should emerge within a relatively short time scale. The hard costs were identified as about $66,400 but the human and organisational costs were not considered in detail. The directly measurable benefits (cost reductions and time savings) are provisionally estimated at a value of about $564,000 halfway through the work on the building. Some of the quantitative and qualitative benefits have already been achieved. Examples of these are shorter access time to find information, reduced costs of distribution, better information available for decision-making and better version control. About halfway through the work on the building the researchers have estimated that about $60,000 has been saved on distribution costs alone and this is almost enough to cover the fixed costs.

The single most important factor for the realisation of the benefits of the IT system is the resistance to using the system by the end users. This has led to a slower achievement of the IT system's benefits. In spite of this problem some benefits have already emerged but, since the project is still under construction, most of the data collection is based on estimation and only a little data on the achieved benefits has been collected.

5. INTERACTION BETWEEN TIME FACTORS

The case studies show the type of benefits that can be achieved with new IT systems and that they take longer to arrive than expected. If an assessment can be made of the time taken for system acquisition and process reengineering, the year in which the use of the system reaches adequate, if not full, productivity can be estimated. This can then be related to the cyclical activity of the business or of construction in the countries in which business is carried out.

Using the typical time scales for implementing systems proposed previously, the time in years taken to break even and that by which systems become obsolescent, are estimated as:

	Expected break even	Probable obsolescence	Example
Long term systems	5	10	Management info system
Medium term systems	2	5	Computer Aided Design
Short term systems	1	3	Office automation suite

The stage of the construction cycle at which to start implementing each of these types of system and carry out process change in order to meet the next peak in demand with a fully productive system, should vary. Another factor to consider is the frequency of replacement by the next generation of systems. If an assessment of productivity is carried out after installation of a system, and this is rarely done in any rigorous manner, it should be possible to show the benefits achieved and to make a case for the replacement in the IT budget.

Figure 4 shows an idealised activity cycle with 5 years between peaks, and the optimum stages of the cycle at which to start implementing long, medium and short term systems. If the period for implementation stretches across a low point in workload, it may be difficult to sustain the investment necessary but, if this can be done, it is an ideal time in which to carry out training and prepare to meet the demands of the next peak. Each replacement of a system with a new version requires less investment since experience has already been gained.

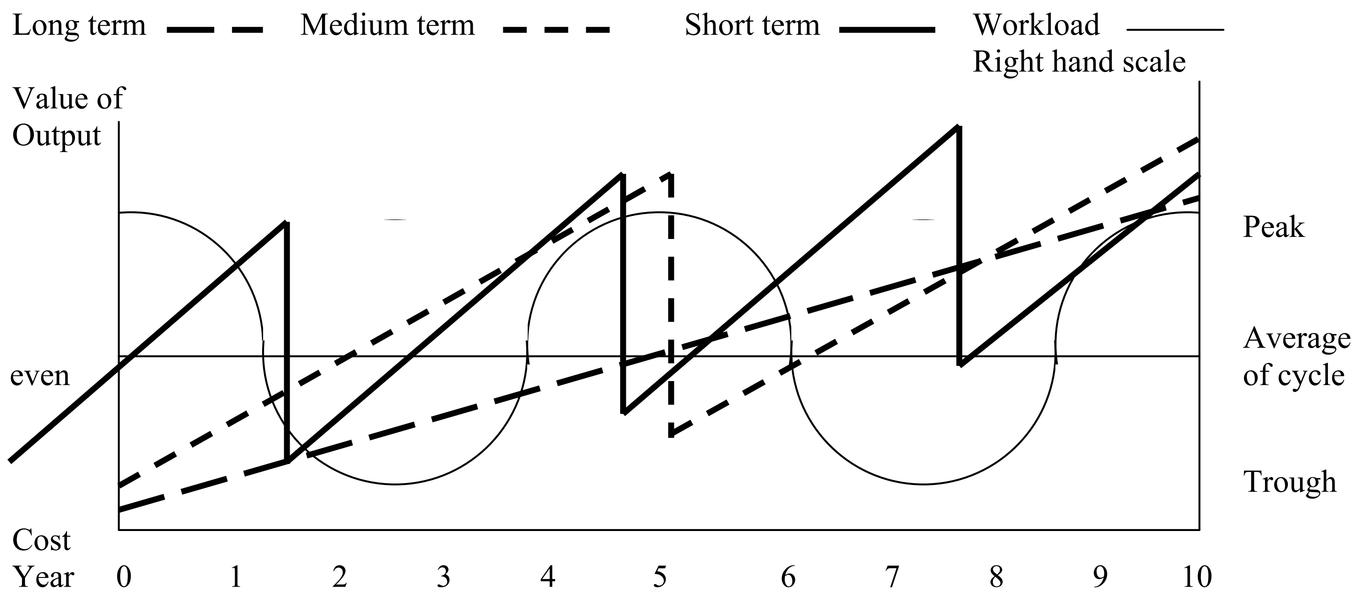

Figure 4. Optimum times related to cyclic workload for introducing different types of system

6. CONCLUSIONS

One of the reasons for the productivity paradox is that those introducing new IT systems underestimate the time to get them into full production and to make the necessary changes to their organisation. Many systems thought of as short term may, in fact, be medium term systems owing to the length of time required to gain full experience of their use. With medium term systems, such as CAD, the first system that is operational over five years, may only enable the users to generate unstructured drawings. This may provide measurable benefits, but the next generation of systems, operated by experienced people, will allow data to be structured, libraries of standard components to be assembled, and even 3D models to be used for more than visualisation. It is from this that a different order of benefits may come. The third phase of the development may then allow sharing of model data with project partners and a further order of benefits may result. The original drawing production might have increased productivity by creating the necessary drawings with fewer people, but the later stages will add qualitative benefits in the form of better coordinated project data, fewer errors on site and a faster exchange of information between partners.

The fluctuations in workload in countries where this is cyclical are hard to predict, in the size of the fluctuations if not in their regularity. The current period of sustained growth in the UK construction industry, and recent reports on changing the whole process, have resulted in some major changes in leading projects encouraged by the Best Practice Programme [12]. This experience should create an environment in which more fundamental process change allows even greater benefits from IT, provided they can be timed to take into account the next drop in workload that is sure to occur. Governments now believe they have inflation under control and that such recessions as that of the early 1990s, will not recur. However there are many possible causes of such recessions and we may not know what will cause the next one.

Experience would suggest that the methods used for assessing the benefits of IT systems, largely qualitatitive ones, as borne out by studies by CIRIA and CICA in the UK [13] and by Andresen in Denmark [2], may be the most appropriate ones in an economy that is hard to predict. Quantification of benefits should be attempted although at least 12 different methods are mentioned by Farbey [14]. What should be more useful is to select the right combination of methods to suit the situation, relating to the state of the economy, the scale of the system and the business benefits sought by the user company. The state of development of the relevant technology, not so early that you are the one to find the bugs, yet soon enough that you have a long period of use before obsolescence sets in, is important as is the phase of the construction workload. Getting the right systems into productivity is not just a matter of investing in hardware software and training, or even in changing the processes addressed by the systems, it is also a matter of realistic estimation of the time to do all this and then trying to start the process at the right moment.

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