



# Current approaches to software quality assurance within the United Kingdom

C.J. Davis, J.B. Thompson, P. Smith

*Commercial Software Engineering Group, School of  
Computing & Information Systems, University of  
Sunderland, Sunderland SR1 3SD, UK*

## ABSTRACT

The high costs to industry of poor quality software resulted in the UK government's department of Trade and Industry (**DTI**) in the late 1980s commissioning investigations on whether quality procedures and standards could substantially improve the quality of software. The findings from these investigations led to the production in 1990 of the TickIT Guide to Software Quality Management System Construction and Certification using EN29001. These developments and the background to them are reported. This is then followed by a report on the findings of a survey which was undertaken at the end of 1991 concerning approaches to Software Development and Quality Assurance and whether or not the TickIT initiative had actually influenced software developers.

## INTRODUCTION

The problem of poor quality software has been a recurring theme within the software industry for more than 25 years. It has underpinned a longterm "Software Crisis" and its existence led to the introduction of the term "Software Engineering" in 1969 [1]. It may also be considered the factor which more than any other has forced the acceptance of Software Engineering as a true discipline and the advent of the professional Software Engineer.

During the late 60s and early 70s efforts associated with reducing the software crisis were mainly directed at code level with very little thought

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being given toward greater understanding of the required system, or better management of software development. During the late 70s and early 80s, there was a change of attitude and the problems of specification, design, measurement, and management began to be addressed. Various techniques were developed that concentrated on the early phases of software development, such as structured design and dataflow design. These techniques have been developed over the past 10 years to become fairly sophisticated and useful design and development methods. In fact over the last 20 years, the information technology industry has seen the introduction of a plethora of tools including text editors, libraries, etc. However, despite these tools, the complexity of the software system still increases and quality continues to be elusive. For, as stated by Miller[2]:

The single biggest obstacle inhibiting the rapid expansion of information technology is the inability to quickly create high-quality, low-cost software that meets the expectations of the computer user and operates flawlessly without human intervention.

It is thus paramount in countering the software crisis that we develop means of effectively quality assuring software.

The remainder of this paper addresses the developments in the field of software quality assurance (QA) that have taken place in the UK during the last fifteen years. It is divided into three major sections. In the first we provide a brief review of relevant QA procedures, costs and initiatives. In the next we present results from a recent major survey which we have undertaken on current approaches to Software development and QA. In the last section we provide a summary of our findings and we make suggestions regarding changes and development which we believe must take place if the current situation is to be further improved.

### REVIEW

In considering Software QA it is important from the outset to appreciate the relationship between a supplier's quality management system and a quality management standard. Slater[3] defines the purpose of the former as:- a procedural framework which actively functions to regulate and assure the quality of products and services provided by the supplier, and the latter as identifying:- general quality requirements which need to be addressed by the supplier's quality management system to meet purchaser or national criteria.

For many years it has been assumed that the same principles of quality assurance should apply throughout the engineering disciplines. Therefore,

it was believed that the same standards and people could be deployed in the quality assuring of the building of a Bridge, as that of building a software system. In many cases the QA engineer would have very little, if any, knowledge about software development. The process of quality assurance, therefore, although part of industrial activity for many years, failed to gain the active support of software developers. As computers move more into life-critical situations, however, the need for reliable systems becomes more urgent. Users are also demanding better quality systems and are increasingly looking for vendors who adhere to nationally or internationally recognised standards.

### QA - The UK Software Industry

Developments in QA during the last 25 years in the UK can be divided into three categories:-

- i. Instruments of change - these are authoritative documents, such as the Warner Report[4] which have stimulated change and other documents which by their nature have forced change.
- ii. Influential general quality assurance standards, such as those produced by NATO, which have contributed to the development of UK national documents.
- iii. UK national and International QA standards, such as BS5750 and ISO9001, which define quality management requirements and have been used for contractual and assessment purposes.

During the 1980s interest in quality assurance increased, both nationally and in Europe. In 1982 the Governments concern for better standards and quality assurance within the UK was revealed in the production of the white paper "Standards, quality and international competitiveness" [5]. The paper, although not stating anything new, helped provide further impetus to increase efficiency. The BS 5750 Standards began to be recognised as was the value of product certification schemes such as the BSI Kitemark and Safety Mark Schemes. In 1987 BS 5750 Parts 1, 2 & 3 were re-issued with additional guidance material to assist with implementation of the International Standard Organisation's ISO 9000 and European Economic Community's EN 29000. At the same time the Department of Trade and Industry (DTI) promoted the National Quality Campaign to generate a growth of interest in quality assurance within British Industry. The number of BSI registered firms during the period 1981 to 1984 showed a slow rise to a figure of 500. Whereas, the period from 1984 up to 1990 indicated an ever increasing rise to nearly 7,000. However, a very small percentage of these related to Software Development.

The obvious high costs to industry of poor quality software led the UK governments' Department of Trade and Industry (DTI) to commission in 1987 investigations from consultants at Price Waterhouse[6] and Logica[7] regarding QA use. These investigations were to determine the true costs of



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poor quality software, and whether quality procedures and standards could substantially improve matters.

### Cost Of Poor Quality Software

The investigations showed that many billions of pounds were spent annually in the UK on software, by Industry, Government and Commerce. Of this sum, it was estimated by Price Waterhouse that, for traded software only, £520 million per year is being wasted due to poor quality software. These costs can be categorised in terms of :-

|                           | (£ million) |
|---------------------------|-------------|
| * low productivity        | 50          |
| * Project overruns        | 50          |
| * error correction        | 150         |
| * unnecessary maintenance | 270         |

These figures only relate to marketed software produced by UK suppliers, therefore, total failure costs in the UK would have been considerably higher if imported and In-House software had been included. Margaret Dennis[8] from the DTI Software Quality Unit, took this further by assuming that the highest estimate of traded software as a proportion of the total was 15%. Thus, if the Price Waterhouse estimate was multiplied by four, which is seen as still erring on the side of caution, then the total UK figure for cost of poor quality could be £2,000 million per year, or £1 million per working hour.

It is also likely that there are significant indirect costs associated with poor quality software, which are difficult to quantify because they relate to individual users. For example: poor software systems may lead to a lack of confidence in a company and result in a loss of business for that company. Thus poor software quality results in substantial costs, monetary and otherwise to both suppliers and users.

### Use of Quality Assurance Approaches

With regard to the use of QA procedures within the UK software industry Price Waterhouse reported:-

The measurement of software quality is difficult and much work remains to be done to develop satisfactory software quality metrics. A number of studies have attempted to define a set of measures, but the results are so complicated that they are of little general use.

Few software producers collect quantitative information relating to software quality. Neither do users quantify the costs they incur as a result of poor quality software. However, despite the difficulty in obtaining quantitative measures, it is generally agreed by both suppliers and users that poor quality software is a major problem.

With regard to organisations adopting QA standards for software they stated:-

ISO 9001 provides an adequate specification of the minimum requirements for a quality system. However, it is at a high level of generality, the terminology is difficult to interpret for software, and the guidance documentation is confusing.

They also recommended:-

that research should be undertaken with a view to developing a workable definition of software quality, and measures of quality and quality related costs that can be easily implemented by software developers.

The Logica Report[7] arrived at similar conclusions and their main recommendation was the establishment of a sector based scheme.

### Developments

To determine the type of scheme that was best suited to the software industry the British Computer Society (BCS) was invited to propose the organization, procedures and rules for a sector scheme which was compatible with emerging CEC documentation (Commission of the European Communities). The BCS decided to work within the framework that already existed, but to use a fresh approach. The result was the collection of guidance material procured from various sources to form the document called the TickIT guide [9].

It was hoped that the TickIT guide will help reduce misconceptions by interpreting the application of ISO 9001 to the development of software (ISO 9001-3). Also, it was hoped to gain the confidence of the IT sector by strengthening the areas of weakness: Auditor registration and training, guidance and certification body practice.

### UK QUALITY ASSURANCE SURVEY

In late 1991 a survey [10] of the use, in the UK, of QA procedures was undertaken as part of a research project at the University of Sunderland into the wider aspects of Software Engineering practices. From a dispatch of 500 questionnaires 151 usable replies were received. The responses came from a wide range of business types with the most frequent being Software Houses, Banking and Manufacturing. Three of the main aims of the survey were:-

To determine the use of Quality Assurance[QA] Procedures within the UK IT industry, with special attention to those with 3rd Party Certification.

To assess the relationship between users of software development

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techniques/methods and Quality Assurance Procedures.

To determine reasons for developers seeking/not seeking a Quality Assurance Standard.

### Use of QA Procedures within the UK

Out of the 151 usable replies received from the survey, 89 (59%) respondents stated that they did use a quality assurance procedure and 62 (41%) stated that they did not. The 89 respondents that used a Quality Assurance Procedure were further broken down into whether their Quality Management Systems were assessed to First, Second or Third Party.

The three classes of assessment as defined in the TickIT Guide[8] are:-

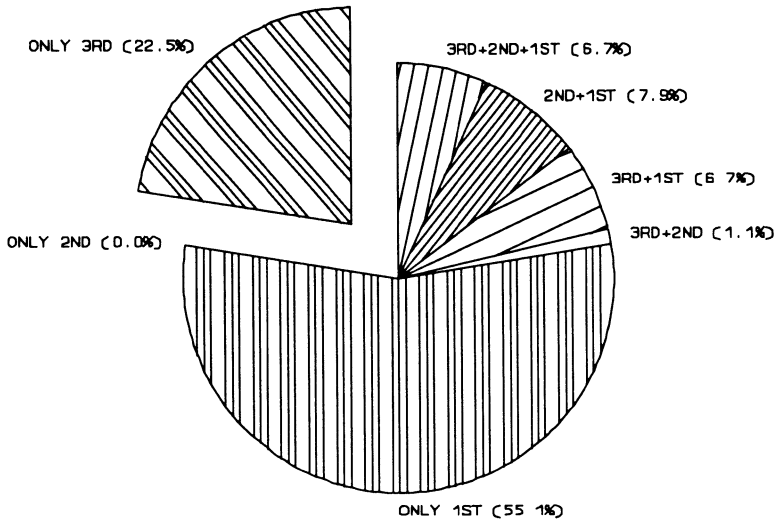
**First Party Assessment** is when the organization assesses itself. This is normally done by the process of internal Quality Management Systems [QMS] review.

**Second Party Assessment** is when an organization is assessed by a purchaser of its products against product or quality system standards selected by the purchaser organization. Second party assessment may be relatively narrow in scope because normally the purchasing organization is only permitted to examine elements relating to its own products; however, they can provide a sharper focus in a particular area. Successful assessment is signified by the award of a certificate by some major purchasers.

**Third Party Assessment** is where an organization is assessed at its own request by some external body which is not a direct purchaser, invariably to a national or international standard. Such an assessment examines the full range of a supplier's activities within an agreed business scope by the evaluation of representative projects. Successful assessment is signified by the award of a certificate (certification).

Throughout the remainder of this paper respondents have been classed as either having no recognizable quality assurance procedure [**Non Q.A.**], a quality management system assessed to First or Second Party assessment [**Q.A. Procedure**], or Third Party assessment [**3rd party**].

Out of the 89 respondents who stated that they did use a quality assurance procedure, 68 stated that they were 1st party assessed, 14 were 2nd party assessed and 33 third party. This showed that some respondents must obviously be using more than one standard. On further examination the figures showed that, in this sample, 55.1% of the respondents assessed their own quality management system. Another interesting observation is that no-one within our sample used 2nd party assessment on its own, it was only applied along with either a 3rd or 1st party assessment. This breakdown is illustrated in Fig.1.



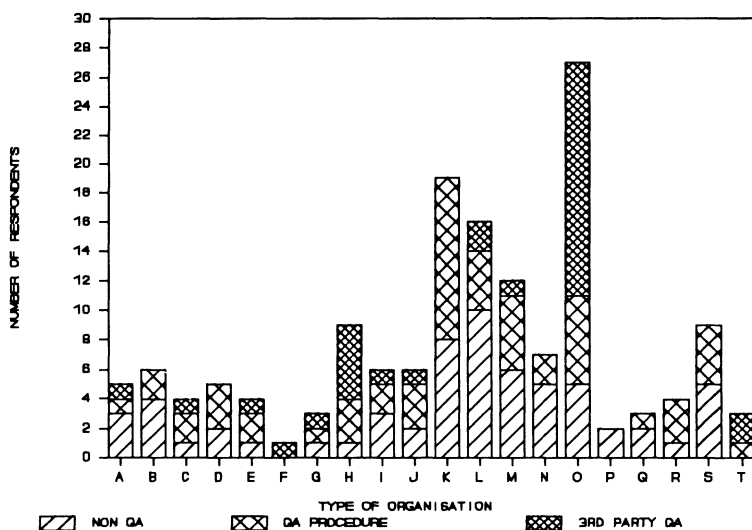
**Fig.1** Use of Quality Assurance Procedures (for 89 respondents)

### General Background Information

Respondents were asked their type of business, size of organisation, number of people employed on software development and the size of projects undertaken. With the exception of Research, a Q.A. procedure was applied within each business type. The percentage of Q.A. applied within each business type according to the number of responses was calculated. Within this sample Computer Manufacturing gave a 100% response to using a Q.A. procedure, but as can be seen; the response is small. Computer Consultancy and Software Houses had the highest percentage with a reasonable response, with 89% and 81% respectively. Engineering Software Development, Education/Health and Food were all joint third with 75%. The average percentage of Q.A. procedures within business types was 58.19%.

Business types with Q.A. were further broken down into those with First, Second and Third Party Assessment, as illustrated in Fig.2. Software Houses and Computer Consultancy still showed a high percentage with 59% and 56%. The average percentage of Third Party Assessment within business types was 21.95%.

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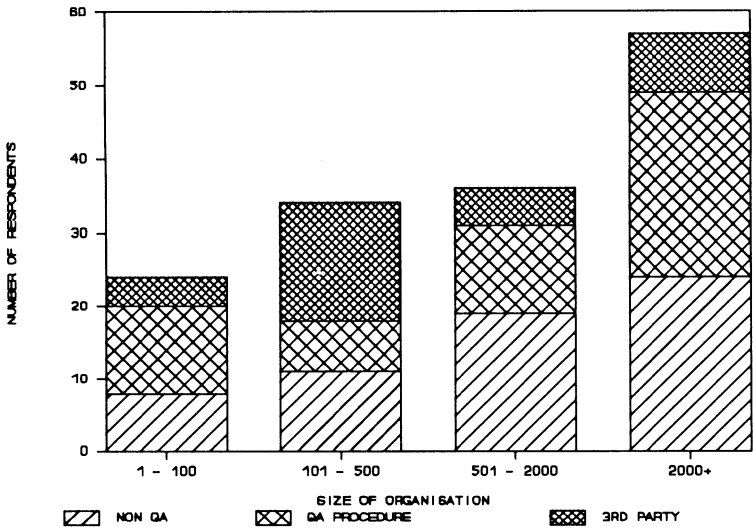
**Fig.2** QA procedures within business type

Electronics/Telecommunications . . . . . A  
Engineering Soft. Development . . . . . C  
Education/Health . . . . . E  
Engineering/Construction . . . . . G  
Transport/Travel . . . . . I  
Banking . . . . . K  
Insurance . . . . . M  
Software House . . . . . O  
Media . . . . . Q  
Retail . . . . . S

Government National/Local . . . . . B  
Fuel and Energy . . . . . D  
Computer Manufacturer . . . . . F  
Computer Consultancy . . . . . H  
Public Utility . . . . . J  
Manufacturing . . . . . L  
Automotive . . . . . N  
Research . . . . . P  
Food . . . . . R  
Other . . . . . T

Organisation Size

Respondents were asked to indicate the size of their Organisation/Branch by the number of staff employed, the response is shown in Fig.3. Substantially more responses were received from organisations with over 2000 employees, 57 (38%). The two ranges in between were quite even at 34 (22%) and 36 (24%), with organisations of 1-100 staff being noticeably less. Quality assurance was looked at in conjunction with organisation size to try to establish a link with the size of an organisation and the likelihood of it using a quality assurance procedure. These figures are further broken down in Table I to show the number of respondents within each size category that had 3rd Party Assessment.



**Fig.3** 3rd Party assessment within size of organisation

The initial analysis shows, that for this sample the percentage of Q.A. was greater within the two smaller sized groups, i.e. number of employees = 1-100 and 101-500, 67% and 68%, whereas the 2000+ showed 58% and the 501-2000 showed 47%. Moving to 3rd party assessment, however, there is quite a substantial drop in all but the 101-500 group, which retained a reasonable 47%, compared to two 14% and 17% in the other three groups.

**Table I**

| SIZE     | NUMBER OF RESPONDENTS | NUMBER OF RESPONDENTS WITH 3RD PARTY |
|----------|-----------------------|--------------------------------------|
| 1 - 100  | 24                    | 4                                    |
| 101-500  | 34                    | 16                                   |
| 501-2000 | 36                    | 5                                    |
| 2000+    | 57                    | 8                                    |
| TOTAL    | 151                   | 33                                   |



Techniques/Methods

Respondents were given a list of methods/techniques that could be used in the production of software, under the headings of Project Control Management, System Specification/Design Phases and Program Specification/Design Phases. They were asked to indicate which method/technique they used and whether the usage was Low, Medium or High, this information was then cross referenced with their use of QA approaches. A typical analysis of their responses is shown in Fig.4.

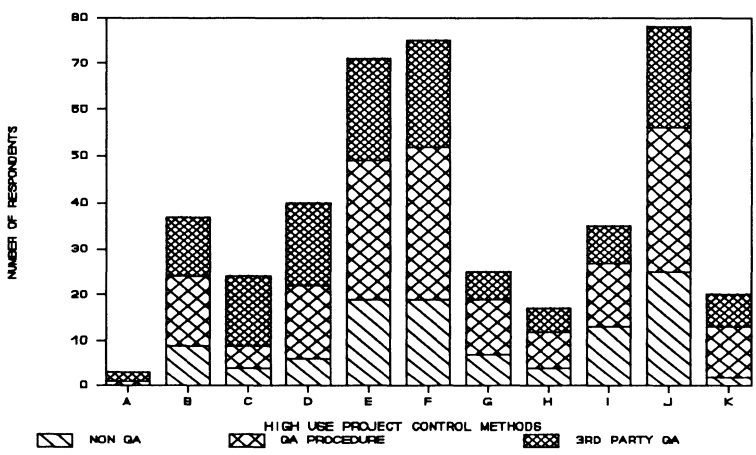


Fig.4 High use project control management methods with Quality Assurance

- |                                         |       |   |
|-----------------------------------------|-------|---|
| PRINCE                                  | ..... | A |
| Stage Documentation                     | ..... | B |
| Configuration Management                | ..... | C |
| Software Design Procedure               | ..... | D |
| Change Control                          | ..... | E |
| Formal Project Plan                     | ..... | F |
| Project Diary                           | ..... | G |
| Integrated Project Software Environment | ..... | H |
| Structured Walkthrough                  | ..... | I |
| Regular Review Meetings                 | ..... | J |
| Other                                   | ..... | K |

The major results from this analysis are:-

Project Management Approaches For those respondents using QA high use was reported for :-

Change Control  
Formal Project Plans  
Regular Review Meetings

The reported use of PRINCE was particularly low, both in organisations using QA and those that did not.

System Specification/Design Phase Approaches Those respondents using QA reported high use of :-

SSADM/LSD/Variant  
Prototyping  
Data Flow Diagrams

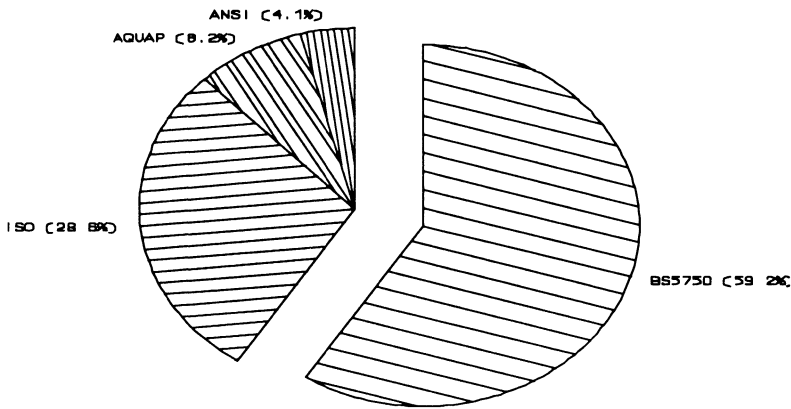
Relatively little use was made both by respondents using QA and those that did not of:-

VDM (Vienna Development Method)  
JSD (Jackson System Development)  
Gane/Sarson  
Information Engineering/Navigation Series

Program Specification/Design Phases Both organisations using QA and those that did not made high use of Modular Programming approaches. They also reported a significant use of Top Down design approaches. Organisations using QA procedures also reported high use of JSP (Jackson Structured Programming). However, there appeared to be little use of Warnier/Orr or Yourdon/Constantine in either organisations using QA and those that did not.

#### Use of Quality Assurance Standards

The respondents that already had third party assessment were asked to list the current standards applied to their software development. The results are shown in Fig.5. The responses showed that some respondents were assessed to more than one third party standard. An analysis of which standard and how long these standards had been applied within each organisation is given in Table II.



**Fig.5** Third Party Assessment currently applied (for 33 respondents)

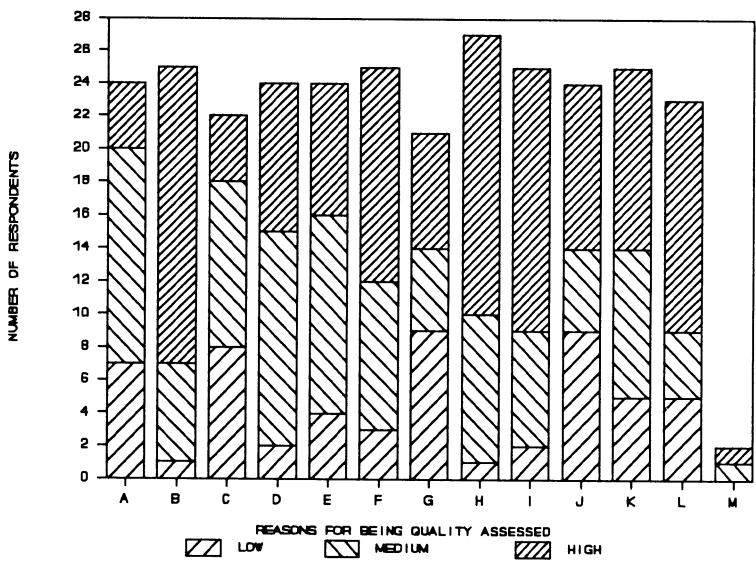
**TABLE II**

| EXTERNAL<br>STANDARD    | NUMBER<br>OF<br>RESPON-<br>DENTS | LESS<br>THAN<br>1 YEAR | 1-2<br>YRS | 2-3<br>YRS | 3-5<br>YRS | OVER<br>5<br>YRS |
|-------------------------|----------------------------------|------------------------|------------|------------|------------|------------------|
| BS5750 ONLY             | 18                               | 10                     | 5          | 1          | 1          | 1                |
| ISO ONLY                | 2                                | 2                      |            |            |            |                  |
| BS5750 +ISO             | 7                                | 3                      | 1          | 1          | 2          |                  |
| ANSI ONLY               | 1                                |                        | 1          |            |            |                  |
| BS5750 + ISO +<br>ANSI  | 1                                |                        |            |            | 1          |                  |
| BS5750 + ISO +<br>AQUAP | 3                                | 1                      |            |            | 1          | 1                |
| ISO + AQUAP             | 1                                |                        |            |            |            | 1                |
| TOTAL                   | 33                               | 16                     | 7          | 2          | 5          | 3                |

When asked if the organisation had applied a Q.A. standard before the current one, 14 replied that they had, and 19 that they did not. Of the 14 that had, 11 were their own Q.A. standard, 1 was a second party standard and 2 were third party, both of which were AQUAP 1/13.

Reasons for seeking Third Party Assessment

In an effort to establish reasons for seeking third party assessment a list of possible reasons were given with the respondent asked to indicate whether they felt the influence was low, medium or high. The possible reasons and the responses are shown in Fig.6. Clearly the major reasons are; commercial success, to increase profits, to produce a system of known quality and to satisfy the user.



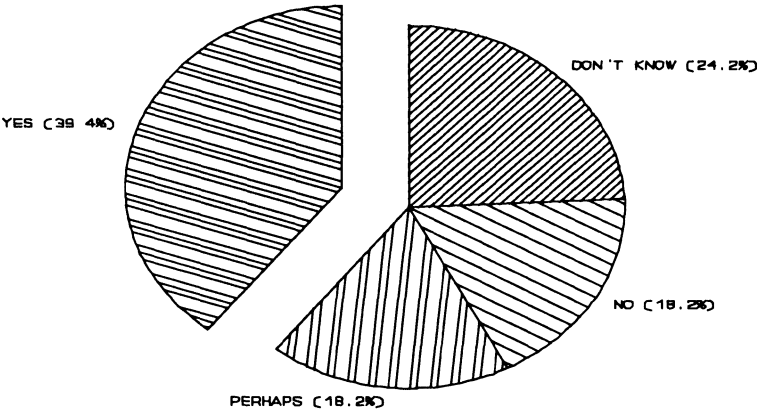
**Fig.6** Reasons for seeking 3rd party assessment (for 33 respondents)

|                                |       |   |
|--------------------------------|-------|---|
| Reduction of development costs | ..... | A |
| Commercial success             | ..... | B |
| To increase productivity       | ..... | C |
| To reduce project overrun      | ..... | D |
| To reduce maintenance cost     | ..... | E |
| Earlier detection of errors    | ..... | F |
| To increase profits            | ..... | G |
| To improve reliability         | ..... | H |
| To produce a system of known   |       |   |
| quality                        | ..... | I |
| Pressure from purchaser        | ..... | J |
| To receive certification       | ..... | K |
| To satisfy user                | ..... | L |
| Other                          | ..... | M |



TickIT Initiative

Respondents were first asked if they were aware of the TickIT Initiative. Of those respondents who already were 3rd Party Assessed, 77% were aware, and 24% were not. For those who were not 3rd Party Assessed the situation was almost reversed, with 30% aware and 70% not aware. Respondents also provided information about whether or not they would be seeking TickIT certification in the near future. The overall response to this question is shown in Fig.7 with a further breakdown given in Table III.



**Fig.7** Respondents seeking TickIt certification in the near future

**TABLE IV**

|               | 3RD<br>PARTY<br>ASSESSED | NOT 3RD<br>PARTY<br>ASSESSED |
|---------------|--------------------------|------------------------------|
| DON'T<br>KNOW | 8                        | 20                           |
| NO            | 6                        | 41                           |
| PERHAPS       | 6                        | 31                           |
| YES           | 13                       | 26                           |

## CONCLUSION

Overall our survey has shown that there has been an increase in the use of QA standards within the software industry from that reported by Price Waterhouse [6]. However, the situation is still far from ideal and there is obviously much room for further improvement. With regard to the aims of our survey which we highlighted at the start of the previous section we can draw the following conclusions:

There is still a large percentage of software systems being produced without any QA procedures. Forty one percent of our respondents admitted to not using any QA procedures. Also, of those respondents who confirmed that they were using a QA procedure the majority (55%) used their own QA procedures rather than an external one. The situation is probably actually worse than these figures suggest, for several reasons. A survey on QA is likely to generate more responses from those that are using QA procedures (and could be considered positive to the subject) than those who are not. Follow up questionnaires to previous surveys have indicated this is often the case [11]. The number of respondents claiming to have a QA procedure should be treated with caution because often what is in fact very little may be regarded as a full internal QA procedure. Also our questionnaire simply asked whether a QA procedure was operated for software development - we did not ask to what extent the procedures were really used! Nevertheless, 22% of respondents were already using third party QA procedures and the majority of those not currently using third party felt that their business may or would benefit in the future by adopting a third party QA standard.

With regard to relationships between software development techniques/methods and QA procedures it is difficult to identify any definite links. It appears that overall, organisations using QA procedures are more likely to be using well defined and modern techniques/methods than those that are not. What is perhaps more interesting are the facts, as reported above, that certain techniques/ methods which one would expect to be associated with QA were little used.

In the area of organisations adopting QA standards the major reasons for seeking third party assessment were identified as: commercial success, increased profits, to produce a system of known quality and to satisfy the user. The major reasons for not seeking such assessment were: current methods are satisfactory and the extra time needed to implement any new procedures. With regard to the TickIT initiative it appears that this has

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been reaching the converted but has been failing to reach the majority of those who were not using third party QA procedures. What is particularly disappointing is that this sector is the one that needs the information most.

We now intend to progress our investigations further by means of in-depth interviews with selected respondents to our survey.

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