

Project information systems: quality assurance linked to information technology

K B CAMERON
Quality Manager
Gardiner Willis and Associates
284 Victoria Avenue
Chatswood NSW 2067
Australia

ABSTRACT

The construction industry, slow to react to management initiatives in the past must now rapidly adapt to the emerging technologies that are being implemented in industry world wide. This paper provides an introduction to the concept of quality assurance and examines the implementation of quality management systems within the design and construction industry. By looking at the requirements for a quality system and its application to this industry, there emerges a need to document and control the flow of information, resulting in the project information system. The emerging information technologies can be linked with the development of quality assurance to provide an enhanced project information system through the lifecycle of a facility.

Key Words

Quality assurance; information technology; management systems; project information systems;

Introduction

The emergence of quality management systems, through the implementation of quality assurance is a world wide phenomena that is affecting all industries. First developed through defence establishments, the quality movement has spread to general manufacturing and now into service industry providers.

Given that construction is simply manufacturing done once, quality systems can be equally applied to the design and construction industries. By examining the requirements of a documented quality system a direct link can be made with emerging information technologies.

What is quality assurance

Quality assurance (QA) is a management tool that can be defined as a systematic method of definition, planning, implementation and review of process within an organisation in order to provide adequate confidence that a product or service will satisfy given requirements for quality. By formally documenting the way the organisation operates and establishing a control system to monitor its implementation, the organisation can ensure the quality of its productive effort.

By definition, the process of documenting how an organisation operates will force the management to look at alternative methods and thus fine tune systems within the



organisation which will improve productivity and profitability. A key element to this process is the control of documentation, how it is developed, how it is transferred between the parties, and how it is stored and maintained.

The world wide push for quality has been linked by the formation of the ISO 9000 series of quality standards. These establish a formal process by which organisations can develop a system which can be independently assessed and awarded international recognition.

Total Quality Management (TQM) takes the fundamental concept of quality assurance into a total management environment focusing on customer needs and expectations linked to a process of continuing improvement. This paper does not discuss at length the attributes of TQM, however the development of a quality assurance system should be seen as a precursor to implementing Total Quality Management.

The emerging information technologies now available lend themselves to a union with quality assurance to result in highly efficient management tool.

In Australia, quality assurance has been implemented in the construction industry since the early 1980's. The push was at first through power station construction, however high profile projects such as the Parliament House building in Canberra (the Australian national capital) have resulted in a general acceptance within the industry for the development and implementation of quality systems. CIDA, the Construction Industry Development Agency, has recognised the need for the Australian construction industry to implement quality systems and is guiding government purchasing policy on both a national and regional (state) level. Major construction firms in Australia are in the process of implementing quality systems, and in turn forcing their "suppliers", the design consultants and sub contractors to also implement quality systems.

Gardiner Willis and Associates (GWA), a medium size consulting engineering practice began implementing a quality system in January 1990, which culminated in our certification of our quality system to ISO9001:1987, "Quality Systems for design/development, production, installation and servicing" in May 1992. GWA is the first member firm of the Association of Consulting Engineers, Australia (ACEA) to gain recognition as a quality endorsed company. From this position we are observing the rapid implementation of quality assurance through out the construction industry.

While the concept of quality assurance has developed from manufacturing industries, it can be readily adapted to the construction industry. A parallel can be drawn to the emergence in 1960's of project management within the aerospace industry: it has now become a management tool that is applied to all industries, especially the construction industry.

In the future there will be an increasing need to obtain, store and retrieve data to enable the effective control of construction projects. The emergence of information technology provides exciting opportunities for this industry. By linking this with quality assurance, a tool to speed up implementation of quality assurance, and more importantly its cost effectiveness to the project will be enhanced.

How is quality assurance applied to the construction industry

The application of quality assurance should be seen at two levels, specific to an organisation and generated for a project.

Organisation quality system

The organisation quality system will consist of:

(a) The quality manual

This summarises how the firm has applied a quality system. This is the way in which the organisation can communicate its system to outside parties and demonstrate how it has applied the relevant quality standard.

(b) System procedures

These documents establish who does what when and where in order for the effective operation of the quality system. Procedures also will establish what records are to be established to demonstrate the compliance with the system.

(c) Work instructions

These third level documents will establish the how and why of the procedures, and explain in detail the steps to be followed in complying with the defined operational process.

(d) Quality records

In order to demonstrate the application of the quality system, records covering critical items of the quality system must be maintained. The nature of these records are summarised below:

- review of the management system;
- contract review;
- design inputs and outputs;
- design verification processes;
- changes to the agreed scope of work;
- approved suppliers;
- purchase orders;
- client supplied product;
- identification and traceability of product;
- production process information;
- inspection and test records;
- calibration records for inspection, measuring and test equipment;
- control and disposition of nonconforming product;
- corrective action applied to the system;
- training.

The word "product" is the goods or services produced by the organisation.

The nature of the above in particular, and quality systems in general lend themselves to the application of information technology to better manage the process. In fact, document control, which encompasses the maintenance of records is a key (and often misunderstood) element of any quality system.

The above are essential elements of the management of the organisation, which has been addressed by other papers of this conference.

Project quality system

A project quality system will include the following:

- design plans (or programme), including the allocation of resources;
- design verification activities;

interface requirements;
inspection and test plans.

The above will be a project specific application of the various elements of the base quality system. For small projects, the project quality plan will be a simple adjunct to the organisation quality system.

For a larger project, a individual quality plan may be developed by the head contractor/project manager and this system would be communicated to all members of the project team: the client, design consultants, contractors, subcontractors, inspection agencies and end users. This quality plan would establish the nature and type of records to be kept and their format and location.

Quality system development, incorporating the planning aspects of a project quality plan is becoming an integral part of the management of projects. Application of the quality standards has resulted in a common approach and readily interfacing documentation.

While a quality system is established in order to increase the quality of the productive effort for a specific project (finished product, cost and time) it also presents a unique way of controlling the project and providing a record of activities that can be utilised when planning or bidding future work, and also referred to during the life cycle of the project.

The development of the project information system can be based on the project quality plan, developed by the quality assurance system. Thus by using a systematic process of definition, planning, implementation and review of the project a dedicated project information system can be developed and maintained.

The current utilisation of quality assurance within the construction industry

Project Initiators

There is an increasing requirement with government bodies for the implementation of quality assurance. In the Australian state of New South Wales, Public Works Department guidelines require the demonstration of an operational quality system for all consultant commissions in excess of \$A20,000 and all construction projects in excess of \$A1,000,000. Similar guidelines exist or are in the process of implementation throughout Australia.

Companies involved in the manufacturing sector are increasingly demanding quality assurance implementation as part of the tender qualifying process. The building and mineral sectors are also beginning to seek quality system implementation.

The push for the development of quality systems on construction projects works both ways - if the end user requires the implementation of a quality system on a project, they in turn must have implemented a quality system within their own organisation if they are to maintain effective control.

Feasibility studies

Very little has been developed for the process of feasibility studies, apart from where this is a part of the overall operation of a quality system. However the concepts of design development can be applied to this process. As quality system usage proceeds, the amount of available comprehensive information (records)

established in a uniform format will result in the increasing use of quality assurance in this phase of a project.

Design Phase

Probably in excess of 50% of all design consultants in Australia are in the process of implementing a quality system, and the remainder are aware of the increasing requirements for quality assurance. Industry groups, such as the ACEA have developed generic models to assist their members to develop and implement a quality system. Several large consultant firms have recently gained certification of the quality system. Gardiner Willis and Associates have now over three years experience in the operation of our quality system.

For the design phase of a project, the quality system concentrates on:

- (a) establishing the form of agreement between the consultant and the head contractor/ project manager;
- (b) formulating a design plan which allocates resources for both the design and verification phases and establishes the points for interface review by the design team, and updating this plan through the life of the project;
- (c) establishing the design input criteria and the documented form of the design output;
- (d) establishing the process for design verification;
- (e) establishing the process for the identification, documentation, review and approval of design changes;
- (f) establishing the method for the control of project documentation;
- (g) the records to be maintained.

All the above, and document control in particular, lend themselves to the application of information technology to expedite the design process.

To date design consultants have tended to operate their quality system in isolation of other members of the design team. With time and the increasing sophistication of the service users, the implementation of quality assurance will accelerate, resulting in a coordinated approach of all members of the design team.

The management of design has been addressed by other papers at this conference.

Construction phase

Major infrastructure and resource projects within Australia generally require the implementation of a quality system. All members of the project team are compelled to have a system in place. In the past the head contractor has had to develop and implement a system for their sub-contractors. Sub-contractors that have developed a quality systems now have a strategic advantage when seeking work from head contractors.

The articles by Burroughs and Soady highlight the effectiveness of the implementation of quality systems. The key is the need to effectively plan the work in order to implement a quality system.

For the construction phase of a project, the quality system concentrates on:

- (a) establishing the form of agreement between the client and the head contractor/ project manager;
- (b) establishing the control of the design phase of the project (where applicable: refer to above detail given in the design control);

- (c) establishing the process for the identification, documentation, review and approval of design changes;
- (d) establishing the method for the control of project documentation;
- (e) establishing the purchasing requirement for a project;
- (f) establishing the process for the control of free issue items;
- (g) establishing the construction control requirements;
- (h) determining the requirement for inspection and testing;
- (i) determining the process for the control of nonconforming installation;
- (j) providing the control for the handling, storage, packaging and delivery of items for the project;
- (k) establishing the identification, collection, indexing, filing, storage, maintenance and disposal of records for a project.

The head contractor will establish their requirements for inspection (including the requirements of the client) into the tender documents for each phase of the works. Sub-contractors will develop their own inspection and test plans incorporating these needs. There is a high level of document control and this highlights the opportunities that exist for the emerging information technologies.

The nature of quality assurance lends itself to the fast tracking of projects: standard pro-forma can be quickly transferred into a documented project quality plan, standard procedures can be modified to suit project requirements, highly trained and motivated staff can absorb this information and get on with the project. Applying quality assurance to a construction site requires detailed planning at the start of the job which in turn will expedite the project and achieve the fast track.

The intention is to build quality into the project, not inspect it in. To achieve this there has to be a high level of communication of requirements between the parties, based on the project quality plan and developed into the Project Information System. This communication can be best handled by the emerging information technology.

Maintenance phase

The increasing sophistication of modern design and construction is coupled with the budget restrictions of clients. A design lifecycle of twenty to forty years require materials of appropriate standard (to project budget) to be used and a regular programmed of maintenance to ensure the continuing serviceability of the facility.

Total Quality Management seeks out continuous improvement in all facets of an organisation. Applying quality assurance will allow a firm to effectively manage the maintenance phase of a project, the tools of TQM will allow the organisation to analyse process to determine future improvement.

The above requires both a plan of action, and the collection and analysis of data to determine the potential for improvement. information technology can be applied to provide a mechanism for this.

The project quality plan developed through the feasibility, design and construction phases provides a detailed record of the what went into to developing the facility. This information can be drawn upon to assist in the maintenance phase.

With the increasing number of organisations adopting QA/TQM processes, it is likely that there will be increased utilisation of the information maintained in the project quality plan. The potential to integrate information developed through the course of construction by the use of information technology to provide a record for reference during the maintenance phase highlights a potential future direction.

Disposition phase

As the construction of a facility requires detailed planning and the use of engineering design and project management, so to does the disposition phase.

The sophistication of many structures provide complex future problems through disposition. In some cases, the demolition of the facility has to be engineered at the design stage. The use of information technology to provide a record of all phases of the lifecycle of a facility will in turn provide a basis for planning the disposition.

Current utilisation of information technology within quality assurance

A brief observation of the current utilisation of information technology in the developing quality assurance systems highlights the future potential for emerging technologies.

Quality system documentation

The merging of quality system documentation for separate sites/geographic locations has been achieved within Australia. In this, the various types of documentation are established on a computer network, with updating of the system occurring instantaneously from a central base.

Preparation of Project Quality Plans and Inspection and Test Plans

With the development of quality Assurance there is an expanding library of documented quality plans. Using simple word processing techniques these can be assembled for a project. For larger firms, the linking of various sites with a database of previous plans is possible using information technology.

Document Control

A critical and least understood area of quality assurance is the need for document control:

"The supplier shall establish and maintain procedures to control all documents and data..."
(clause 4.5.1 of ISO 9001:1987)

A document control system, including relevant procedures has been developed by Hard Copy Pty Limited of Sydney. This system enables the organisation to accurately track the flow of documentation by utilising a data base. This simple application of information technology demonstrates the compatibility with quality assurance and the potential for future development.

Electronic data interchange

The use of electronic data interchange (EDI) is being encouraged by the application of quality assurance. A major client of GWA is moving towards total document transfer by EDI by mid 1995, linked to the purchase requirements of a quality system developed to ISO 9001:1987.

Purchase agreements developed by companies with quality systems developed in accordance with the ISO 9000 series can include the requirements for EDI. One of the methods for assessment of acceptable suppliers (as required by clause 4.6.2 of ISO 9001:1987) is their ability to service the needs, such as EDI, of the purchaser.

Quality systems developed to the ISO 9000 series obligate the purchaser to establish their requirements (such as EDI) in the purchaser documents (refer to clause 4.6.3 of ISO 9001:1987), and for the supplier to carry out a contract review which ensures that all requirements are adequately defined and documented and includes the capability of the supplier to meet contractual requirements (refer to clause 4.3 of ISO 9001:1987).

Advantages of using quality assurance

A central tenet of any quality system is the process of planning, reinforced in the procedures.

An associate company of Gardiner Willis and Associates recently completed a small construction project (value \$A200,000) in Sydney. Other tenderers had quoted a period of fourteen weeks to the client. The company gave an undertaking to complete the work in ten weeks and was awarded the contract. By applying the process of quality assurance, with all phases of the work documented in a project quality plan, the project was completed in eight weeks. The result, an accurate record of all phases of the construction, a client who is providing more opportunities and the bonus of costs saved in minimising the time on site during construction.

In the GWA design office, twenty percent less time is spent in drafting than before the implementation a quality system. Figures of savings of 12% of formwork costs have been quoted in the industry through the utilisation of quality systems. There is a growing body of evidence of tangible real savings in time and materials by firms who are utilising quality systems, for example the paper by Burroughs looks at methodology used to quantify the cost savings of applying quality assurance to a construction project.

An additional benefit in the adoption of quality systems is the changing of the culture of an organisation. The construction industry is characterised by personnel who tend to apply their way of doing things, fail to keep adequate documentation and rely on others to resolve outstanding problems. A quality system requires the adoption of a common approach to the way the organisation operates, requires a minimum standard and type of record keeping and forces people to recognise and resolve problems as and when they arise.

To achieve the above, there will have to be a great deal of education and retraining of staff members to forgo a confrontationist approach and instead adopt a proactive approach to construction. The implementation of information technology is likely to require a similar approach, highlighting the benefits of combining these two emerging technologies for implementation within the industry.

Development of a Project Information System linked to quality assurance

The above discussion highlights the potential to use the tools of quality assurance to develop a project information system, from the initial concept design through the lifecycle of a facility.

The project manager or head contractor would establish the project quality plan incorporating the document control system at the commencement of the project.

The purchasing documents for design consultants would establish the required standards for CAD and other software to be used for the design process, and the document exchange process utilising EDI. The project quality plan would establish the planning and interface requirements, and common procedures linked by a network would be updated as required through the design phase.

Construction contracts would incorporate the requirements for the inspection and test plan, which again would be established on a computer network. As built drawings could be updated through the course of the work and transferred using EDI. Design queries would be referred back to the originator with a control system established to monitor their resolution.

Compatibility of information technology would be achieved through the establishment of a standard system which forms part of the procurement process. The necessity to establish up front the project requirements will aid in the successful completion of the project.

A comprehensive record of activities will be controlled by the operation of the inspection and test plan. These will contain objective evidence of the means used to assure the quality of the construction phase of the project. These records, linked with the drawings and specifications maintained in an integrated network will provide the basis for the ongoing maintenance of the facility. This information can be drawn upon and combined with records of ongoing maintenance to aid in the decision making process.

At the end of the life cycle of the facility, this body of information can be drawn upon to develop the best means of disposal.

All the above requires a management system to control the generation, storage and retrieval of information. Quality management for a project requires a dedicated information system. Linking the project information system developed through quality assurance with the emerging information technology indicates the future direction for the construction industry.

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