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System information modelling in practice: Analysis of tender documentation quality in a mining mega-project

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ABSTRACT

The quality of information contained in tender documentation produced using Computer-Aided-Design (CAD) and provided in a hard-copy format to an electrical engineering contractor for a port expansion facility, which formed an integral part of an Iron Ore mega-project is analyzed. A System Information Model (SIM), which is an object oriented approach, was retrospectively constructed from the documentation provided to assist the contractor with their tender bid preparation. During the creation of the SIM, a total of 426 errors and omissions were found to be contained within the 77 tender 'drawing' documents supplied to the contractor by an Engineering, Construction, Procurement and Management (EPCM). Surprisingly, 70 drawings referenced in the tender documentation, and the Input/Output lists and Cause/Effect drawings were not provided. Yet, the electrical contractor was required by the EPCM organization to provide a lump sum bid and also guarantee the proposed schedule would be met; the financial risks were too high and as a result the contractor decided not to submit a bid. It is suggested that if the original tender documentation had been prepared using a SIM rather than CAD, the quality of information presented to the contractor would have enabled them to submit a competitive bid for the works. The research concludes that the economic performance and productivity of mining projects can be significantly improved by using a SIM to engineer and document electrical instrumentation and control (EIC) systems.

1. Introduction

Design and engineering is only effective when it serves its intended purpose and is constructible within desired budget, time, quality and safety objectives [1]. An electrical instrumentation and control (EIC) contractor, for example, must be supplied with high quality information so as to enable them to construct their work effectively and efficiently and without hindrance [2–7]. Rarely, however, is the design and engineering of EIC documentation for mining projects produced with all the necessary information being made available when tenders are sought [8]. More often than not contractors are supplied with incomplete, conflicting and erroneous documents [9]. In addition, contractors are often required to submit a tender within a limited time frame. In such a case, a considerable amount of contingency may be incorporated into the bid, especially if requests for information (RFI) fail to provide information needed to ensure works can be carried out efficiently and effectively. Consequently, bids can be inflated and/or render a project unfeasible.

In this paper, the quality of information in the tender documentation provided to an electrical engineering contractor for a port expansion facility (which formed an integral part of an Iron Ore mega-project) is analyzed. Notably, such information is rarely made available for analyses due to its commercial sensitivity. Moreover, there has been limited empirical research that has examined the quality of information contained in the documentation that has been prepared to solicit tenders. Such research, however, is needed to demonstrate the prevailing issues that adversely impact the costs of mining projects to clients.

The participating contractor is hereafter referred to as 'Contractor A' to preserve confidentiality agreements made between both parties. The aim of this paper is to examine the nature of errors, omissions and information redundancy that were presented in the tender documents and the potential risk exposure that the contractor would have faced in the field should they have been awarded the project. To address the deficiencies contained within the drawings provided in tender documents

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for EIC systems, it is suggested that the use of an object oriented approach, referred to as a System Information Model (SIM), to design and document the project instead of Computer-Aided Design (CAD) can significantly reduce the occurrence of errors, omissions and information redundancy [2–6]. Thus, a SIM can be integrated with a Building Information Model (BIM), yet the use of software applications of this nature to produce EIC object models are rarely used in the Australian mining sector [6]. Yet in the mining industry, EIC accounts for approximately 29% of the world's capital expenditure on plant. Furthermore, in plant operations, EIC typically accounts for 60% of maintainable items as well as being critical to safe and efficient operations [6]. Despite their importance, there has been limited research that have examined EIC systems within an object oriented environment within the construction, energy and resources sectors [5,10]. A SIM forms an integral part of the BIM nomenclature and has been described in detail in Zhou et al. [7].

2. Case study

Thus, against this contextual backdrop, the following research question is examined in this paper using a case study: Is a SIM able to provide significant cost and productivity improvements during the production of design and engineering documentation for EIC systems? To address the aforementioned question, triangulation was used as the basis for data collection process, which took place at the offices of an electrical engineering firm who had been invited to tender for a system upgrade for an existing Port Facility.

Triangulation involves the use of multiple research methods and/or measures of a phenomenon, in order to overcome problems of bias and validity [11,12]. Data collection methods employed were unstructured interviews, observations and documentary sources (e.g., tender documents). In addition to the active day-to-day interactions between the participating organization and lead researcher, unstructured interviews with key personnel were also undertaken by a secondary researcher. This approach was undertaken to provide additional context to the problem and provide validity to the research process.

2.1. Background

Growing demand for iron ore from countries such as China and India has stimulated the development of existing facilities to better accommodate increased iron ore production from 45 Million tons per annum (Mtpa) to 155 Mtpa. The expansion project (referred to as T155), situated in Western Australia (WA), required additional port facilities and rail systems. Company Iron Ore (IO) procured the project using an Engineering, Procurement, Construction and Management contract (EPCM). In this instance, the EPCM contractor assumes responsibility for coordinating all design, procurement and construction work.

The expansion project consisted of two parts: (1) the facility upgrade at the existing port; and (2) the construction of a rail spur to the two new mine sites. The railway spur was approximately 135 km long connecting the mainline railway to the newly developed mine sites which include an airstrip, operations and construction accommodation, plant, roads, power, water, fuel, utilities and stockyards. An upgrade to the existing mainline railway was also undertaken to enhance the rail system's capacity. A 155 km duplication of the selected section of the mainline rail was also constructed to connect the port and an existing mine site.

The port facility's upgrade was planned to be completed within three stages. Stage one, referred to as T60, constructed a second outloading circuit, which increased the port's export capacity from 45 Mtpa to 60 Mtpa. The works that had been completed were dredging, installation of a new wharf for the third berth, a shiploader, sample station, reclaimer, two transfer stations and all the conveyors between them. Stage two provided the port with the second and third inloading circuits. The work involved the installation of two new train unloaders, a stacker, three transfer stations, the conveyors between them and the associated equipment. Stage three involved an additional outloading circuit, which increased the port's export capacity further to 155Mtpa. The work involved the construction of a new wharf for the fourth and fifth berths, a shiploader, reclaimer, sample station and all the interconnecting conveyors and Transfer Stations.

2.2. Control system upgrade for port facilities

The control system expansion of the port facilities were also implemented in three stages in accordance with the project schedule. In Stage one (Upgrade to 60 Mtpa) ten new High Voltage (HV) and Variable Speed Drive (VSD) switch rooms were constructed and linked into the existing T45 network. Stages two and three consisted of constructing 21 HV and VSD switch rooms which were tied back into stage one's T60 network.

The tender documentation that described the control system upgrade requirements of the existing port facilities were provided to several Electrical Engineering firms for review prior to bidding for the works. The tender invitation was sent to potential contractors on 12/04/11. The tender submission deadline was 03/05/11, which meant that interested applicants needed to complete the activities identified within three weeks. A lump sum bid was required for the control system by 'Company IO' and all work specified in the contract was required to be completed by the specified date. In addition, it was explicitly stated that any cost overrun incurred by latent uncertainties and insufficient information contained within the contract documents were at the contractor's risk.

2.3. Tender documentation

The tender documents comprised of 126 files, containing a total of 1687 pages. The tender documents studied in this research described the requirements of the control system installation, Programmable Logic Controller (PLC) and Supervisory, Control and Data Acquisition (SCADA) software development of the port facilities. Fig. 1 illustrates the structure of the proposed control system after the expansion project. In addition to the existing system, the port facility expansion project requires new field devices, marshalling panels, switch rooms and the cables to be installed on site. The newly introduced devices were required to seamlessly interact with the existing system forming an integrated monitoring and control system, which would provide information for the plant operation managers' supervision. In preparing the tender, an electrical contractor would typically undertake the following steps:

- allocate a dedicated engineering team to undertake the tender;
- read through the 126 files (1687 pages) provided as part of the tender package;
- determine the system functions and requirements to be achieved;
- examine the 77 contract drawings and estimate the quality of the required equipment to construct the control system;
- identify errors and omissions contained in the contract drawings;
- raise an RFI to the principal's engineering team seeking clarifications of the problems identified;
- investigate the principal and technical specifications and determine the proper classes of the equipment and cables required by their corresponding safety classifications;
- estimate the Input/Output(I/O) points of the expansion system;
- investigate the existing T45 system to determine the interface and control schemes between the proposed and existing systems;
- clarify the functions to be coded so as to realize the required control system functionalities;
- define the Human Machine Interface (HMI) graphics;
- estimate and calculate the cost of equipment, cables and software;