Agile Maturity Model Approach to Assessing and Enhancing the Quality of Asset Information in Engineering Asset Management Information Systems

(Research in Progress)

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Abstract

This paper proposes a maturity model for assessing and enhancing the quality of asset information in engineering organisations. It is also intended to assist in the enhancement of the collection, storage and use of engineering asset information with the aim of enhancing the Information Quality (IQ) in order to improve organisational learning and decision making. Action research methodology is adopted to allow researchers to test and further refine this model with relevant Engineering Asset Management Organisations (EAMOs).

Keywords: Engineering Asset Management, Information Systems, Information Quality, Maturity Model

1. Introduction

This paper explores Information Quality Management (IQM) issues in EAMOs. More specifically, an agile information quality management maturity model is proposed to act as a tool for assessing the quality of asset information. The model will also provide guidance (instead of a rigid set of rules) on how to systematically raise the maturity level, thus helping enhance the quality of EAM information.

Many large organizations need to fully define an EAM business process as well as associated IQM processes [Martin 2004; Saunders et al. 2004]. Furthermore, EAM information of poor quality directly impacts asset managers' decision making; poor information may result in incorrect decisions which result in increased costs [Chengalur-Smith, Ballou & Pazer 1999; Friedman, Ted 2002; Ballou, Madnick & Wang 2003; Johnson & Dasu 2003; Knox 2004a, c; Parssian, Sarkar & Jacob 2004]. Therefore, information quality assessment becomes critical to EAMO. Given the notion that effective IQM processes result in quality information [Caballero, Gómez & Piattini 2004; Kyung-seok 2005], the maturity model presented in this paper will guide the information quality assessment by examining the quality of processes relating to information definition, capture, storage, exchange and so on.

The maturity model approach to quality assurance has already been successfully used in the software engineering community [Harter, Krishnan & Slaughter 2000; Capability Maturity Model® Integration (CMMI), Version 1.1 2002; Hotle et al. 2003]. The Capability Maturity Model (CMM) and the Capability Maturity Model Integration (CMMI) are well known methodologies used to develop and refine an organization's software development process [Farkas & Walsh 2002; Hotle et al. 2003]. They describe five maturity levels, which represent an evolutionary path of increasingly structured and methodically more mature processes. In this paper we have adapted the maturity model philosophy to IQM in EAM Information Systems (EAMIS), since by separating IQ goals in several levels (as in CMM and CMMI), it is easier to achieve partial IQ objectives in an incremental way [Caballero, Gómez & Piattini 2004]. Even though, a number of IQ maturity models have been proposed [English 1999; Laney 2002; Caballero, Gómez & Piattini 2004; Kyung-seok 2005], most of them are very generic (very high-level) and they also do not take various EAM specific processes (asset register, asset hierarchy, performance monitoring, maintenance management, etc.) into consideration. In other words, the proposed model in this paper has a specific focus on engineering asset management processes, which is thought to be a valuable contribution to the existing literature.

2. Information Quality

IQ has been defined as "Fitness for use" [Juran, Gryna & Bingham 1974; Redman 1998; Tayi & Ballou 1998; Wang, RYA 1998] and it is one of the critical problems facing organizations today [Redman 1998; Parssian, Sarkar & Jacob 2004]. “Fitness for use” however implies that the concept of IQ is subjective, which means that information with quality considered appropriate for one use may not possess sufficient quality for another use [Tayi & Ballou 1998; Kahn, Strong & Wang 2002]. Therefore, assessing IQ is a challenging task. Furthermore, even though conventional view of IQ has meant “Accuracy”, research findings have identified a range of IQ dimensions or quality goals including believability, completeness, relevancy, timeliness, security and so on [Wang, R.Y. & Strong 1996]. As a result, an IQ problem can be defined as any difficulty encountered along one or more quality dimensions that renders data completely or largely unfit for use [Strong, Lee & Wang 1997].

Contemporary organizations heavily depend on information systems and the underlying information for everyday operation [English 1999; Huang, Lee & Wang 1999]. Consequently IQ has become a critical concern of organizations and is an active area of Management Information Systems (MIS) research [Lee et al. 2002]. In industry, IQ has been rated regularly as a top concern in data warehousing projects and despite a decade of research and practice, only ad hoc techniques are available for measuring, analyzing, and improving IQ [Lee et al. 2002].

2.1. The Extent of IQ Problems in Industry

In recent times, there has been a rapid increase in the quantity of information available to and used by organizations, as well as reliance of organizations on that information [Ballou, Madnick & Wang 2003]. However, reports from META group indicate that 75% of companies in US have yet to implement any IQ initiative [Beg & Hussain 2003]. Furthermore, one study, of a major manufacturer, has found that 70% of all orders had errors [Wang, Richard Y., Ziad & Lee 2000]. Additionally, a Gartner survey shows that many financial services providers (FSPs) are experiencing operational and decision support initiatives hampered by suboptimal quality information, and that at least 40 percent of companies undertaking a CRM strategy are unaware of IQ problems in their environment [Friedman, T., Nelson & Radcliffe 2004; Knox 2004c]. Moreover, many organizations recognize the existence of IQ problems but do little about it because of a lack of perceived value [Friedman, T., Nelson & Radcliffe 2004]. Therefore, there is a growing need in industry for tools and methods which can be used to assess and enhance the quality of information.

2.2. Impact of Poor Information Quality

IQ is pervasive and expensive with IQ problems costing hundreds of billion dollars each year [Redman 1998; Johnson & Dasu 2003]. The impacts of poor IQ range from operational inconvenience and ill-informed decision-making to complete stoppage of business operations [Chengalur-Smith, Ballou & Pazer 1999; Huang, Lee & Wang 1999; Ballou, Madnick & Wang 2003; Parssian, Sarkar & Jacob 2004]. Furthermore, inadequate information quality has serious implications for customer satisfaction (and thus retention) as well as operational costs and financial reporting [Knox 2004b]. Therefore, by ensuring that organizations are operating with quality information, or at least by being able to estimate the quality of information available, many of these problems can be minimized.

2.3. Enhancing the Quality of Information

2.3.1. Total Data Quality Management TDQM

MIT's Total Data Quality Management (TDQM) program has adapted the quality improvement cycle from the manufacturing industry to IQ enhancement (Figure 1). TDQM applies the "Plan, Do, Check, Act" cycle from Deming's Total Quality Management (TQM) literature [Deming 1982] to Information Product (IP) creation [Wang, RYA 1998; Huang, Lee & Wang 1999; Allen et al. 2003; Shankaranarayan, Ziad & Wang 2003] emphasizing that IQ improvement depends on continuous feedback to the processes producing the information. Therefore, TDQM supports the notion that effective information management processes will result in quality IP, however TDQM does not detail specific processes having an impact on the quality of asset information.

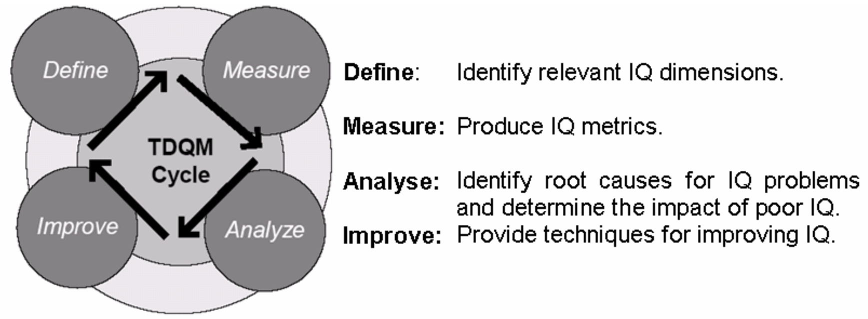

Figure 1. TDQM Cycle Source: [Huang, Lee & Wang 1999]

2.3.2. Information Cleansing

The quality of information can also be enhanced through the process known as Information Cleansing (IC). As a well-recognized method, information cleansing refers to the action of detecting and correcting dirty information. However a Gartner report has found that IC solutions are employed in a minority of asset management information systems [Knox 2004c]. Furthermore, even though a number of IC software tools are available on the market [Friedman, Ted & Bitterer 2005], none of them are specifically designed for EAMIS and most IC software products currently available focus on Customer Relationship Management (CRM) systems. IC can be seen as a small part it the bigger IQM picture since not all errors can be detected, nor can all errors that are detected be easily corrected [Knox 2004c]. Therefore, the maturity model presented in this paper will also take into account various IC functions such as information profiling, matching, enhancement, monitoring and consolidation, for the purpose of enhancing the quality of asset information.

3. Engineering Asset Management

Industry has recently put a strong emphasis on the area of AM and the need for asset information has increased significantly [Asset Information Guideline 2001]. However, serious IQ problems have been identified in existing EAMIS [Martin 2004; Saunders et al. 2004]. Since poor quality information leads to incorrect decision making, which in turn results in increased costs, there has been a growing need for tools and methodologies which can manage and assess the quality of information in EAMIS.

An asset is anything of economic value that is owned by an organization. However, this paper focuses specifically on Engineering Asset Management (EAM) which is the process of maintaining the physical assets, such as buildings, plants or other infrastructure. The term 'Asset Management' refers to the management of assets during their entire life cycle; specification, manufacturing, deployment, maintenance, operation and subsequent retirement of assets all need to be effectively managed (Figure 2). Therefore, AM has been defined as "The process of guiding the acquisition, use and disposal of assets to make the most of their service delivery potential and manage the related risks and costs over the entire life" [Asset Management Series: Principles, Policies and Practices 1995].

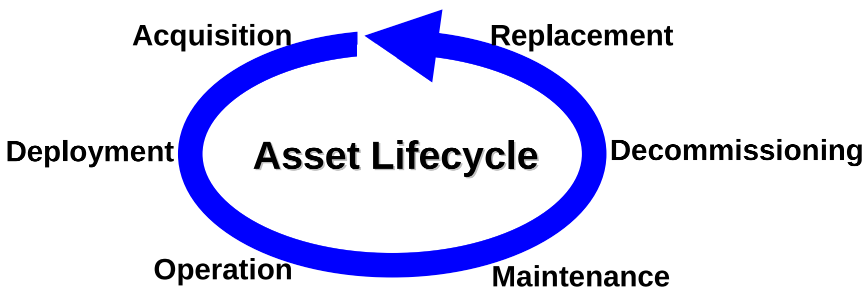

Figure 2. Asset Lifecycle

3.1. Engineering Asset Management Information

Quality information is a crucial aspect of EAM. Moreover, although quite different from tangible assets, information itself can be seen as one of the most important assets. For instance, various performance information can be used to predict future performance and if system performance is to be measured, related information need to be captured and ascribed [Saunders et al. 2004]. Furthermore, information from EAMIS is used to support various decision-making processes including asset upgrading and replacement decisions. Therefore, poor quality information directly impacts asset acquisition and maintenance, potentially resulting in great economic losses.

3.2. Information Quality in Engineering Asset Management

Many organizations are asset heavy and thus even the very survival of some organizations profoundly depends on managing assets effectively and efficiently. For instance, the replacement value of Australian government's assets is in the order of $371 billion, and each year the public sector spends some $18 billion on asset maintenance [Asset Management 2001]. Therefore, organizations can potentially save a great deal of money by managing assets efficiently. Asset information is very important to organizations because it represents the collective knowledge used to manage assets as well as to produce and deliver products and services to customers [Huang, Lee & Wang 1999; Tuomi 1999; Madnick, Wang & Xian 2003]. Furthermore, since successful organizations excel by exploiting information, given that quality information can be used to create knowledge [Huang, Lee & Wang 1999; Tuomi 1999], asset managers should view IQM as a direct mean to reduce costs and impact revenue [Redman 1998; Beg & Hussain 2003].

Even though serious IQ problems have been identified in EAMIS [Saunders et al. 2004], there has been very little (EAM specific) research done in this area. The existing IQ problems in EAMIS are largely due to the fact that many organizations do not have well defined EAM processes and do not consider EAM as a core business process. Consequently, the lack of processes needed to maintain accurate asset data results in poor asset information [Martin 2004]. For instance, if EAM processes are not fully defined or mapped, information capture becomes a significant problem, hence it is likely that too much information will be collected, that it will be in the wrong format and may be incomplete or that it is collected at inappropriate levels of accuracy and precision [Saunders et al. 2004]. Furthermore, the practice of collecting too much and, in some cases, irrelevant asset information without considering the future uses further adds to existing IQ problems [Martin 2004]. Gartner research has also found that asset managers often manually enter information from production reports into Microsoft Excel or other spreadsheets for analysis, an error-prone process that is difficult to audit and validate [Knox 2004a]. This, in turn, negatively affects the quality and timeliness of decision making that can be supported, as well as internal and external confidence in reporting [Knox 2004a]. Moreover, the operational information environment of asset managers has traditionally been fragmented, with data embedded in specific applications, often using formats proprietary to the particular application [Knox 2004b]. This has been a major barrier for more-efficient (and cost-effective) trade processing, introducing latency and IQ issues because information must be transformed, manually handled or re-keyboarded as it passes between applications [Knox 2004b].

4. Information Quality Management Maturity Model for Engineering Asset Management Information Systems

By adapting the maturity model approach to IQM in EAMIS a method for assessing the quality of asset information will be provided. The model will also provide a basis for evaluating IQM in EAMIS along with the protocols for improving organizational IQM capability. It is thought that enhanced IQM processes will ultimately result in enhanced IQ and that by separating IQM goals in several levels (as in CMMI), it will be easier to achieve partial IQ objectives in an incremental way [Caballero, Gómez & Piattini 2004; Kyung-seok 2005]. The model also defines specific processes for IQM improvements, thus guiding organizations towards higher maturity levels.

Following the descriptions of CMMI [Capability Maturity Model® Integration (CMMI), Version 1.1 2002], maturity levels are made up of a number of process areas (Figure 3). A Process Area is a collection of related practices in an area that, when performed collectively, satisfy a set of goals considered important for making significant improvement in that area. Goals apply to a process area and describe what must be implemented to satisfy the process area. A Practice is an activity that is considered important in achieving the associated specific goal, describing the activities expected to result in achievement of the goals of a process area. Sub-Practices are detailed descriptions that provide guidance for interpreting practices. Maturity levels, process areas and goals are described in this paper. However, this paper will not go into in-depths detail to specify practices and sub-practices.

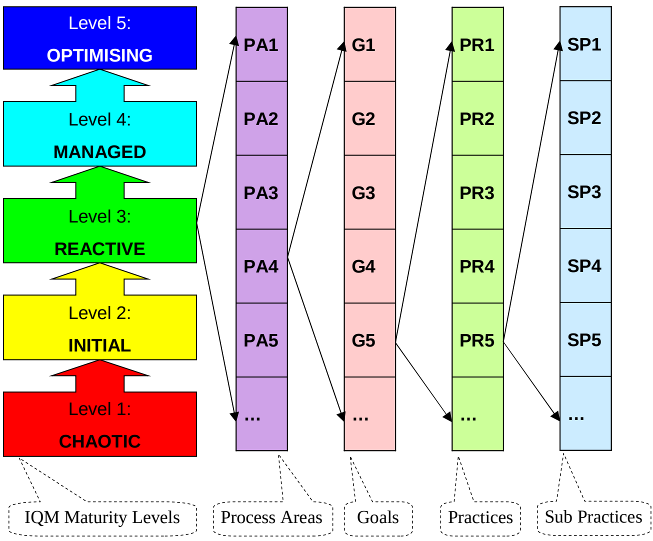

Figure 3. Maturity Levels, Process Areas, Goals, Practices, Sub-Practices (adopted from [Capability Maturity Model® Integration (CMMI), Version 1.1 2002])

Except for Level 1, each maturity level is decomposed into several process areas that indicate processes (as summarized from the literature) an organization should focus on to improve the quality of engineering asset information (Table 1 & Figure 5).

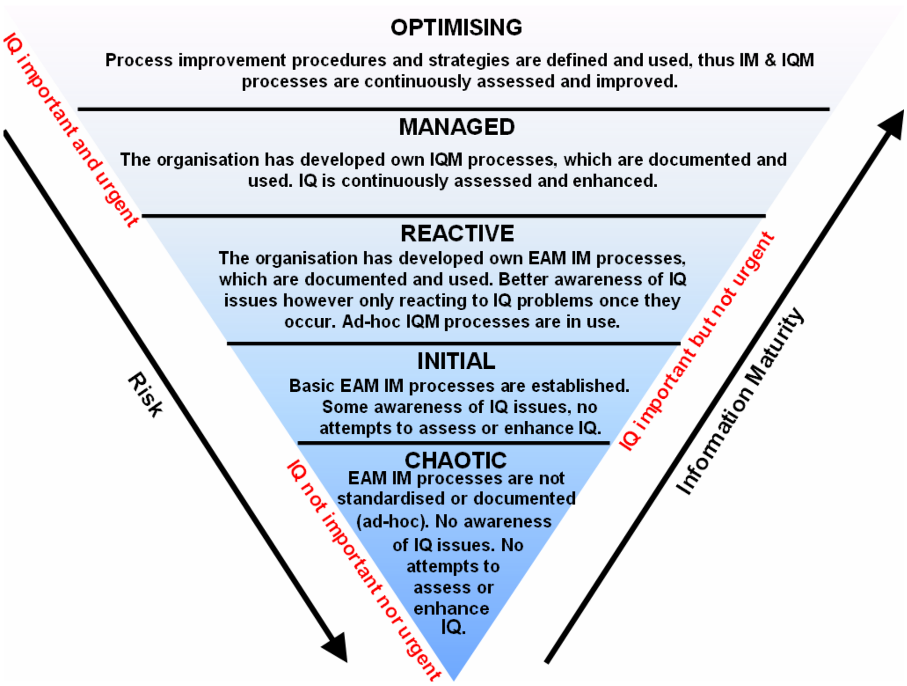

Figure 4. Engineering Asset Management Information Quality Maturity Model

Table 1. Engineering Asset Management Information Quality Maturity Model

Level 1: **CHAOTIC**	*EAM IM processes are not standardised or documented (ad-hoc). No awareness of IQ issues. No attempts to assess or enhance IQ.*
	This maturity level, by definition, does not contain any process areas
Level 2: **INITIAL**	*Basic EAM IM processes are established. Some awareness of IQ issues, however no attempts to assess or enhance IQ.*
	• **Initial Asset Information Management:** o Asset register information management o Asset hierarchy information management o Asset accounting information management o Asset maintenance information management o Contract management information management o Resource management information management

	○ Inventory control information management ○ Condition monitoring information management ○ Performance monitoring information management
Level 3: **REACTIVE**	*The organization has developed own EAM IM processes, which are documented and used. Better awareness of IQ issues however only reacting to IQ problems once they occur. Ad-hoc IQM processes are in use.*
	• **Defined Asset Information Management:** ○ Initial asset information management + ○ Predictive modeling information management ○ Risk management information management ○ Asset lifecycle costing information management ○ Optimizes decision making (ODM) information management • **Reactive Asset Information Quality Management**
Level 4: **MANAGED**	*The organization has developed own IQM processes, which are documented and used. IQ is continuously assessed and enhanced.*
	• **Defined Asset Information Management** + • **Managed Asset Information Quality Management:** ○ Asset information profiling ○ Asset information matching ○ Asset information enhancement ○ Asset information monitoring ○ Asset information consolidation
Level 5: **OPTIMISING**	*IM & IQM processes are continuously assessed and improved. Process improvement procedures and strategies are defined and used.*
	• **Defined Asset Information Management** + • **Managed Asset Information Quality Management** + • **Asset Information Product Management (TDQM):** ○ Define ○ Measure ○ Analyze ○ Improve

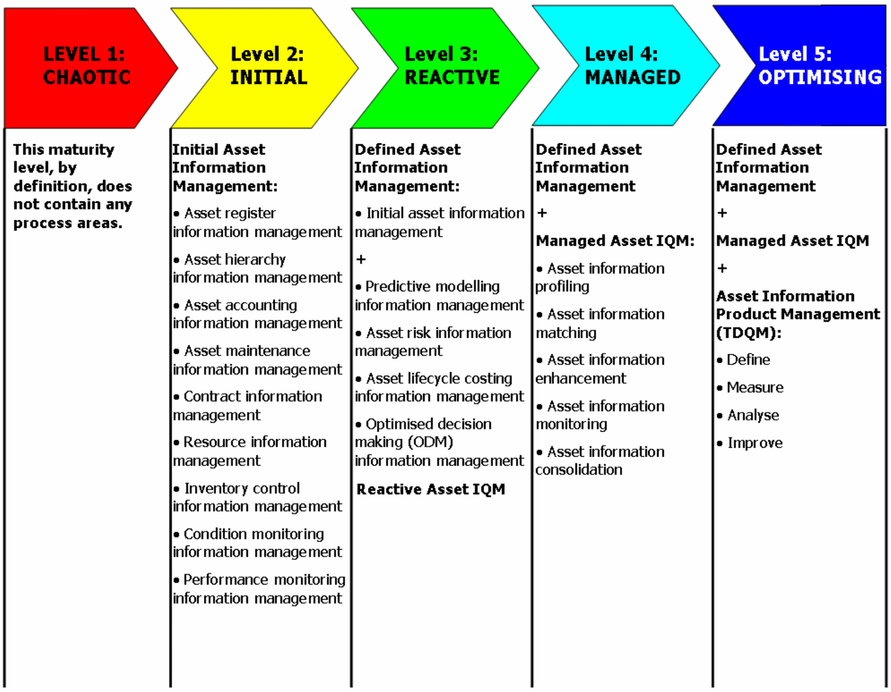

Figure 5. Engineering Asset Management Information Quality Maturity Model

4.1. Level 1 – CHAOTIC

EAM IM processes are not standardized or documented (ad-hoc). There are no processes in place for IQM and there is no awareness of any IQ issues. No attempts are made to assess or enhance IQ. Organizations on this maturity level record very little asset information and do not have a well developed asset management program. This maturity level, by definition, does not contain any process areas.

4.2. Level 2 – INITIAL

Basic EAM IM processes are established. Some awareness of IQ issues is emerging, however there are still no attempts to assess or enhance IQ. Organizations on this maturity level perform basic asset management. Asset register is used to record all assets and asset attributes. Asset hierarchy and any other relationships between assets are recorded as well. Asset accounting is performed to address any legislative commitments as well as to allow for government reporting. Asset maintenance and contract management information is recorded. Resource management information such as job scheduling, monitoring and reporting is recorded. Inventory control, condition and performance monitoring information is recorded as well.

4.3. Level 3 – REACTIVE

The organization has developed own EAM IM processes, which are documented and used. There is better awareness of IQ issues; however organization only reacts to IQ problems once they occur. Ad-hoc IQM processes are in use. Organizations on this maturity level utilize defined asset management, where processes are implemented to manage the assets throughout the asset life cycle. Thus, asset optimization information is managed.

4.4. Level 4 – MANAGED

The organization has developed own IQM processes, which are documented and used. Major IQ problems are identified and the quality of asset information is continuously assessed and enhanced. Various commercial tools are used to perform information cleansing (data profiling, matching, enhancement, monitoring and consolidation). However, the real sources of information quality problems are not actually addressed. There are no programs for process improvements in place.

4.5. Level 5 – OPTIMISING

EAM IM and IQM processes are continually being assessed and improved. Process improvement procedures and strategies are defined and used. Asset information product management processes are in place. Such processes identify the root causes of information quality problems and thus allow for process improvements (preventing the information quality problems at the source).

5. Conclusion

The process of managing engineering assets is profoundly affected by the information used to make relevant decisions. Thus, poor quality information adversely affects EAM, potentially resulting in great financial losses. The maturity model presented in this paper aims to help EAM organizations in assessing the quality of asset information and IQM processes by addressing issues such as information definition, gathering, dissemination, management, exploitation, and so on.

6. Future Work

EAM is an area which requires ongoing research. The adoption of the maturity model concept in asset management organizations with a specific focus on asset management processes is a unique contribution in the IQ field. This model can be used to guide the information quality assessment as well as developing EAM strategies within organizations. This preliminary model was developed from the literature and further research is still required to test, verify and enhance this model.

Where a specific new methodology or an improvement to a methodology is being studied, the action research may be the only relevant research method presently available [Baskerville & Wood-Harper 2002]. Therefore, it is intended to conduct two action research cycles in two large Australian EAM organizations, which will enable the researchers to test and further refine the model. Figure 5 shows how each cycle may lead to improvement of the original model (M1), resulting in a sequence of successively refined and improved models M2, M3…. [Moody & Shanks 2003].

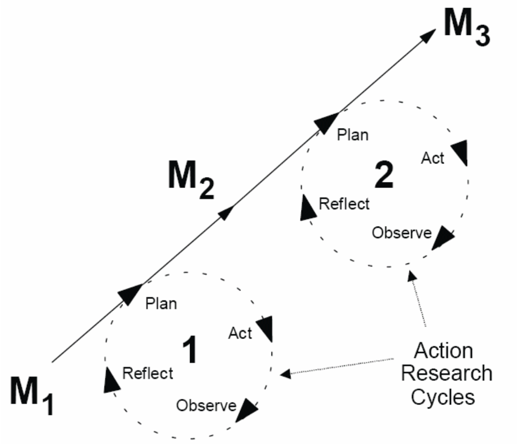

Figure 5. The action research spiral (Source: [Moody & Shanks 2003])

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8. Glossary

AM	Asset Management
CIEAM	Cooperative Research Centre for Integrated EAM
CMM	Capability Maturity Model
CMMI	Capability Maturity Model Integration
CRM	Customer Relationship Management
EAM	Engineering Asset Management
EAMIS	Engineering Asset Management Information System
EAMO	Engineering Asset Management Organization
IC	Information Cleansing
IM	Information Management
IP	Information Product

IQ	Information Quality
IQM	Information Quality Management
TDQM	Total Data Quality Management
TQM	Total Quality Management

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