Data Integrity Issue in Asset-Intensive Industry

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***Abstract*—Fixed asset management is a critical competitive differentiator in asset intensive industries, but the literature on the management of fixed assets focuses on technical issues rather than operational and human concerns. Utilizing an in-depth case study method involving systems demonstrations and interviews, this research assesses that current state of fixed asset management in another of blue chip companies across 5 industry sectors. We conducted a comparative benchmarking assessment that focused on the existing capabilities and completeness of vision for the future of asset management in the asset intensive companies. The research identifies major difficulties with the current methods, technologies used in fixed asset management in these companies, and provides a range of improvements based on the case study data and cross-industry comparison, focusing on people, processes and technology.**

***Index Terms*—data integrity, fixed asset recording, benchmarking, case study, telecommunication**

I. Introduction

Fixed assets management remains an important competitive differentiator for asset-intensive industries such as transport, construction, telecommunication and power & utility. It is of critical importance to organizations in such sectors to maintain accurate and timely records in order to deliver efficient services to customers. A high-quality fixed asset record is essential and the first step in any systematic asset management initiative. Effective asset management supports sound procurement strategies, maximizes asset utilization, streamlines support services, and facilitates end-of-life (or lease) decisions.

However, in reality, the nature of networked assets such as a geographically dispersed asset base and ageing infrastructure often poses significant operational and internal control challenges. The aim of this research is therefore to, via case studies of 7 companies with intensive fixed assets; understand challenges/barriers to a company's ability to manage its record of assets and to identify cost-effective opportunities for further improvements. Our research advances our understanding of the important yet underexplored subject of data integrity issues in fixed asset management in the asset-intensive industry, and lays the ground for further research.

II. Data Integrity in Asset Intensive Industry

Data integrity is a term used in computer science which refers to the reliability, completeness and authenticity of data [1]. Without ensuring data integrity, the usefulness of data becomes diminished as any information extracted from them is not reliable for accurate decision making [2]. The extant literature on data integrity is largely biased towards the technical design of an information system [2-6]; however the human and organizational impact on data integrity has largely been neglected. This is the major driver and novelty of our research.

Data integrity in asset intensive industries is of particular importance. Inaccurate or incomplete record of fixed assets could have detrimental effects on organizations and the society in which the organization operates. For example in September 9 2010, a 30-inch-diameter underground natural gas transmission pipeline ruptured in a residential area in San Bruno, California. The explosion and resulting fire killed eight people and injured 58. The incident affected 108 houses, destroying 38 homes [7]. This accident, according to the investigation of US National Transportation Safety Board, largely attributes to the operator PG&E's ineffective pipeline integrity management program, which was based on incomplete and inaccurate pipeline information.

Asset intensive industries tend to face similar challenges when it comes to fixed asset recording and management.

- Geographically dispersed asset base,
- An ageing infrastructure
- Aging workforce
- Increased regulatory compliance
- A constant drive for service improvement at reduced cost (operational efficiency)

Data integration issues are also common across various asset-intensive sectors, as pointed out by Hanson et al [8] and Etheridge et al. [9];

- Fixed assets not being documented and recorded properly;

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- Lack of governance and control over record management process;
- Incomplete data records of historical maintenance and inspection

Many information systems in asset intensive sectors need human input to capture the data in the first instance before further processing. Though recent advances in automatic data capturing such as RFID and the Internet of Things have made data collection relatively easy, these are not without added cost and technological limitations. Therefore in many practices, data collection as well as data recording and updating in information systems is still largely manual or only semi-automated. A technological solution in itself may not improve data integrity as systematic institutional changes are often required [10]. Therefore the value of this research is as a contribution to the literature by focusing on how data integrity can be improved from an institutional perspective where we take an expanded view and seek to integrate management control, processes, and people with technological solutions.

III. Research Design

Since the primary purpose of the research is exploratory in nature, an in-depth case study approach was considered appropriate as the research attempted to "provide new conceptual insights by investigating individual cases for an in-depth understanding of the complex external world [11]". One of the case companies (hereafter as AG) is one of the largest players in asset-intensive industry and has operations in all five continents. Most of its fixed assets are utility plants. The mix of different generation (both historical and newly added) fixed assets has posed quite a challenge for Company AG. The company is aware of the need to improve its fixed asset record process and management, and hence has worked collaboratively with industry experts to explore this subject.

The research exercise took place between December 2012 and March 2013. The use of multiple data collection techniques, i.e. interviews, system demonstrations, site visits and the use of archival documents were deployed in order to triangulate the research findings [12] and reduce the negative effect of lack of objectivity. This triangulation provides greater reliability of data (as interview data can be verified by other source, for example) and stronger substantiation of constructs. Our research is designed with two-stages.

The first stage of the research concerns primary data collection with the Company AG. A case study protocol was developed in order to guide the data collection with the primary aim to map out the current process of fixed asset recording within the company. Interviews were conducted in order to understand current issues and challenges facing fixed asset recording. In total 12 interviews were conducted (as summarized in Table I). System demonstrations were also conducted in a face-to-face manner in order to understand the current deployment of IT applications for recording and its functionalities as well as potential limitations. Based on the data collected via interview and system demonstrations, an information flow map was developed in order to provide an overall picture of the current processes. Common issues/problems were also synthesized and categorized and critical control areas where need further improvement were then identified.

Our second stage involved a brief benchmark study to compare AG against six other different organizations using a mix of primary and secondary data. The chosen examples are all classed as asset intensive. Those exemplar organization which represent, to our knowledge, some of the best practices in managing fixed assets. In order to ensure data confidentiality of the case companies, we have named our six best practice examples as follow; PU, NR, LU, HA, CT and TO.

TABLE I. Summary of Interviews

No. of interview	*interviewees*	*Interview focus*
2	1)Operational manager 2)Business unit director	- Outline of project scope and deliverables - Overview of the company's operation
2	1) Modeler 2)Asset registering team leader	- Overview of team function - System demonstration: CRM system and Asset record & planning system (ARPS)
2	1) Fixed asset team leader 2) Fixed asset team specialist	- Overview of the lifecycle job planning, job allocation, record returning and update of ARPS. - System demonstration
5	Spare parts planning and management team (5 members)	-Understand how spare parts are being replenished and used by mobile field teams
2	Technical delivery manager Design & architect manager	-Understand IT systems for fixed asset recording from a technical perspective. -Systems demonstration
Total number of interviews		13
Total number of system demos		4

The second stage does not emphasize the depth but rather the width of data collection. It utilizes the primary data which collected previously as part of ongoing work of researchers with organizations NR, LU, HA, CT and TO as well as information available from the public domain such as annual report, media report regarding industrial awards, etc. The data collected from PU is secondary only but sufficient enough for us to conduct the comparative study.

IV. Data Analysis

This section reports our data analysis from both stages. Data collected from first stage enables us to understand the current end-to-end process of fixed asset recording, challenges and issues facing the case companies as well as potential implications on their businesses as a whole. Our second stage benchmark study allows us to compare

company AG' capability and future visionary strategy in fixed asset recording and management with some best practices in other organizations, thus highlighting opportunities for further improvement.

A. Current State Mapping–Case Company AG

The overall process of physical asset recording within Company AG starts by an agent adding component to the existing fixed asset infrastructure. The agent must produce a job pack. This job pack is generated using a work flow system. Once a job pack is generated, it is assigned a unique job number and it goes on onto the asset register, which is designed to track the progress of the job to completion through the return of documentation at the end of the job by the mobile teams. The agent authorizes a job as either YES or NO for the asset registers system, but no matter what status is assigned, it is recorded. A NO job may be a construction or survey i.e. something that does not add or take away from the physical infrastructure. Around 50% of jobs go to the case company internal team and the other half to contractors.

The contractors and internal teams have different methods for returning work. For contractors, as soon as payment is made by Company AG for the work done, the contractor transfers records to Company AG. For internal team, the job pack is currently printed and drawings of the job are done, then sent back and scanned into asset recording system. The quality of data from contractors or internal team is therefore critical for system integrity and the quality of future work.

B. Issues Identified

Through the current state mapping exercise, a number of issues were discovered which contribute to the currently ineffective performance of asset recording and management process within the case company. Information in the asset management system is mostly dated and sometimes inaccurate. Other issues were categorized as people related issues, IT system related issues and management and resource issues and discussed in more depth in the following session.

People related issues: We found that there has been a lack of appropriate key performance indicators (KPIs) to actively encourage accurate recording of assets. IT systems related barriers: There are a variety of legacy systems co-exiting within the company. This has resulted in support and maintenance challenges. For instance the core CRM system which is currently not integrated with asset record system is written in COBOL, and is approximately 25 years old – the company seems to be losing experts who are in possession of this specific language skill. One interviewee from fixed asset team mentioned, "Martin is the expert, but has now left the company. Since then nobody really understands the flag system in asset recording system."

Management and resource related issues: Due to the large and complex size of the company, fixed asset management functions are spreading across different business units. Accounting, finance, IT, planning and network engineers are all part of the process but do not interact collaboratively. Such functional silos could potentially lead to considerable risk of task duplication, delay and different perception of quality and serves as barrier to effective communication. The lack of internal collaboration also indicates a lack of clear ownership and accountability of senior management team.

C. Cross-Industry Benchmarking

In order to ensure data analysis consistency across different organizations, we adopt a framework proposed by Wang and Naim [13] to assess the current capability of digitally managing information. We also extended the framework to include whether the case companies have established a vision in strategic fixed asset management for the future and whether there are any initiatives currently being executed to aid the achievement of the vision – we refer this as 'completeness of vision'.

TABLE II. CROSS CASE ASSESSMENT ON EFFECTIVE FIXED ASSET MANAGEMENT (SOURCE: AUTHORS)

Exisitng capability	Dimensions	sub-dimensions	AG	CT	NR	LU	HA	TO	PU
transactional level	ICT infrastructure(capability)	hardware	1	3	2	2	3	3	2
		software	1	3	2	2	1	3	2
		networks	2	3	2	2	2	2	2
	Connectivity	systems access	2	3	2	2	1	2	2
		linkages	1	3	2	2	2	3	2
		interoperability	1	3	2	2	2	2	2
operational	information sharing	quality/integrity	1	3	2	2	2	3	2
		visibility	1	3	1	3	1	2	2
		speed	2	3	2	2	1	3	2
	process improvement	streamlining	1	3	1	2	2	3	3
		optimisation	1	2	1	2	2	3	3
Strategic	partnering	with exisiting partners	2	3	2	2	2	3	2
		with changing partners	2	3	2	2	2	3	2
	offering	improved services	1	3	1	3	1	2	3
		new services	1	2	1	3	1	2	3
sutotal score			20	43	25	33	25	39	34
Completeness of vision	Understanding needs of EAM		2	3	3	3	2	2	3
	Strategy in place and top mgt commitment		1	3	3	3	3	2	3
	Initiatives launched		1	3	3	1	3	1	3
	Innovative use of ICTs		1	3	1	3	1	3	1
sutotal score			5	12	10	10	9	8	10

Therefore our assessment of each company was two-dimensional: existing capability and completeness of vision. Each dimension was further divided into sub-dimensions, which are summarized in Table II. A simple scale of high, standard and low was then used when assessing each variable, where a score of 3 as assigned to high, 2 assigned to standard and 1 assigned to low. For instance, under Network of ICT infrastructure, a score of 1 implies in-house client-server architecture is in place; a score of 2 means hybrid model i.e. in-house client-server architecture with web interface, and a score of 3 indicates a web-based network system. For detailed definition of each item under 'existing capability', please refer to the work of Wang and Naim (2011). A brief definition of items under the construct of "completeness of vision" was offered as follows;

- Understanding the needs of effective asset management (EAM): the company demonstrates a strategic understanding of EAM and how the market and opportunities are changing.
- Strategy in place and top management commitment: There is a clearly defined strategy by the company and commitment from top management team.
- Initiatives launched: This could include strategic projects (other than quick fix short term solutions) launched in tackling data integrity issue facing the company and committed financial and other resources.
- Innovative use of ICTs: The Company deploys emerging data capturing and visualization technologies such as augmented reality, wireless and sensor network, RFID, and virtual 3D even 4D or 5D modeling.

Utilizing the framework developed above, we are able to apply a graphical treatment and a uniform set of evaluation criteria to enable a direct comparison of asset record and management performance across companies, as shown in Fig. 1. From Fig. 1, we can see that our case company AG is lagging behind in terms of both the current capability of effectively managing fixed asset recording process and future vision.

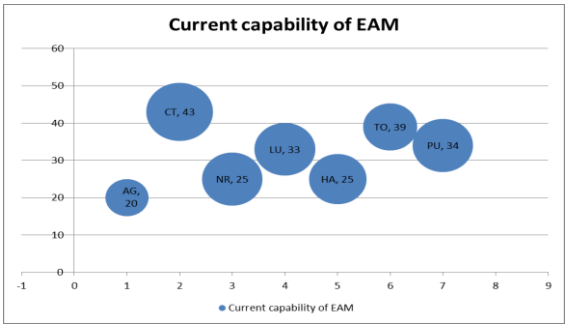

Figure 1. Cross sector benchmarking on effective asset record and management (source: authors)

Meanwhile, Company CT excels in the deployment of advanced technologies for data capturing and top management commitment. The difficulty of timely retrieval of useful information from heterogeneous data sources is a major cause of low productivity in the construction industry (Shin et al 2003). Recognizing this problem, case CT had deployed an advanced Building Information Modelling (BIM) system. BIM synchronizes information with construction practices starting from design, execution, operation, and through to maintenance and renovation; as well as providing information for decision-making throughout a project life cycle. Therefore it breaks the silo effect among various participating organizations in a construction supply chain and connects fragmented processes in a more integrated manner. As a result of this increased connectivity and accessibility, multiple benefits are reported by the case company such as cost savings due to early clash detections between design and construction teams, increased accuracy on cost estimation, reduced errors and better customer service.

NR experiences similar data integrity issues and shares many challenges facing by such Cases as CT and AG. Currently, its asset information is held in a number of differing systems supported by a range of data maintenance and assurance procedures. "We don't have a common view of our assets at present (head of Information Systems at NR)". Therefore its current capability of EAM is scored lower than CT; however a major initiative and £370 million investment was launched in 2011, aiming to make a step change in the collection and use of asset information. Strategy and clear measures are in place. Therefore they score higher on 'completeness of vision. Organization LU has a sophisticated internal process and systems to manage its fixed assets and is trying to build a virtual network that mirrors the physical one. Engineers or other stakeholders can 'walk' through a 3-D modeled network via online access. Case HA, in charge of highway maintenance, has massive data collection via remote road network sensors and used to have 17 different information systems to record and store the data. Losing the visibility and efficiency of asset recording, it is currently integrating disparate asset databases into a new single system at the time of writing.

Case PU has undertaken significant management and organizational change as well in managing its fixed asset recording after a serious accident due to inaccurate asset record lately. A huge record review programme took place to ensure records are traceable, verifiable, and complete and, where they are not, digging up or doing whatever necessary to remedy that. The company has also implemented PAS55, an international benchmark for physical asset management. Therefore it also performs better than the case company in both dimensions.

Case TO has long been known as a leading pioneer in utilizing innovative management practices and technologies to manage its supply chain and assets. For instance, sophisticated information systems are in place that manages its distribution activities. Real time tracking using GPS and telematics is deployed to monitor each individual vehicle's movement and status. This leads to

great vehicle utilization and reduces operating cost such as insurance cost and better utilization of drivers' time.

V. Recommendations and Lessons Learnt

Our analysis of case company AG and a brief cross sector benchmark study confirms that having a detailed, high-quality fixed asset record is essential and the first step in any qualified and coordinated asset management initiative.

For Case AG or any other company which wishes to improve its current practice of asset recording and data integrity, there are opportunities for further improvement as highlighted by best practices in various sectors. Any business improvement initiative will need a systematic change programme in place. Well-known business system reengineering methods or theories can play a significant role in this regard, such as Wattson's UDSO (understand, document, simplify and optimization) method. A comprehensive guide can be found in the work of Kettinger et al [14]. It is not our purpose in this paper to propose how to make organizational changes to improve data integrity. We hope a further empirical study in collaboration with our case company will offer us the opportunity to observe or even influence such change in the near future.

Our recommendations try to address specifically issues identified in Section IV.B. We argue that, as depicted in Figure 2, effective fixed asset recording and maintenance requires the alignment of people, process and technology [15]-[17].

The company should streamline the end-to-end process by removing functional silos and develop an integrated team with finance, operation, planning, infrastructure engineering and IT colleagues for fixed asset record and management functions.

Building on this, clear ownership and responsibilities should be assigned within the team, supported by top management team. Change initiative is unlikely to succeed without the top management team realizing the strategic importance of fixed asset management.

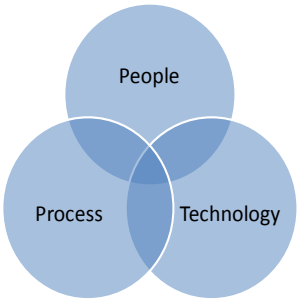

Figure 2. Alignment of people, process and technology for further improvement (source: authors)

With the aging work force in place, the company should also start succession planning bringing fresh talents in the area of fixed asset management and set up proper training across functions to ensure employees are brought up-to-date on essential IT skills in order to fulfill the business's needs.

As to technological solutions, physical verification (either in house or by a 3rd party) as well as automated IT systems could be deployed to enable real time or at least periodic tracking. Technological applications, such as digital pens and paper, allow an instant transmission of documents via wireless communication network back to the control centre. This technology has already seen application in office environments and freight transport. This could be utilized by field engineers and reduce the lead time of record return. The company could aim to build a virtual model which mirrors the physical network of physical assets learning from case LU. Augmented reality deployed by Case CO could also be used in the planning of jobs of and digitization of visualizations of the network.

Finally the company requires proper control and governance mechanisms and appropriate KPIs to encourage and incentivize the accurate and timely return of records.

VI. Conclusion

Fixed assets management remains an important competitive differentiator for asset intensive companies. It is of critical importance for operators to maintain accurate and timely records in order to deliver efficient services to their customers.

This research has advanced our understanding in data integrity – an important but underexplored subject, by identifying a number of key challenges facing asset intensive sectors in maintaining accurate record of its fixed assets and some best practices which are taking place in practice.

Our research is of great value to practitioners as it highlights root causes to effective fix asset recording and maintenance and proposes ways of further improvements. As fixed assets often represent the single largest investment in capital intensive sectors such as utility, construction, telecommunication, energy and gas, even small improvements regarding their management may be translated to substantial cost savings and better return on investment.

The limitations of this research are the focus on a single company and the use of largely secondary material for the comparison with other industrial sectors in the benchmarking section. Future research that will assess fixed asset management using the same methodology across different industries could validate or challenge the findings from this exploratory research and could provide a clearer indication of the state of fixed asset management in industry as a whole.

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