P u b l i c V e r s i o n

# Application of Business Intelligence Dashboards in Enterprise Facility Management

A case study of filling stations in the Netherlands in collaboration with AECOM B.V

**Ali Farokhi**

Delft University of Technology


In Collaboration with AECOM Netherlands

AECOM

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Public Version

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A case study of filling stations in the Netherlands in collaboration with AECOM B.V


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A thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in Construction Management & Engineering


Delft University of Technology



In Collaboration with AECOM Netherlands

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Ali Farokhi

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# Executive Summary

Facility management focuses on the maintenance, development, and enhancement of physical assets to expand and progress commercial value, as well as the design and upkeep of an appropriate physical workplace for the organisation's employees and work (Drion et al., 2012). Enterprise facility management may be challenging with regionally scattered assets and a high number of assets and stakeholders. Filling stations in the Netherlands are not an exception. The Netherlands had 4,147 gas stations, including uncrewed stations, in 2021. Thus, oil and gas corporations have hired third-party engineering consultants to manage their facilities and non-core operations (Potkany et al., 2015). AECOM Benelux, being in charge of the facility management of the filling stations in the Netherlands, manages around 570 stations and more than 50,000 assets.

Managers must make everyday strategic judgments as it's "the core of a manager's job" and "essential to organizational existence." (Robbins, 1991) and (Robbins, 2000). Facility managers quickly grasped the value of data in operational and strategic decision-making. Doing so, they have faced various obstacles, including data overload and biases in their conceptualisation, making them inadequately rational (Molloy & Schwenk, 1995). Due to the human mind's limitations in digesting massive data, decision-makers eventually realized they needed information systems. Numerous computer-based information systems (IS) have been created to aid in decision-making, including decision support systems (DSS), group support systems (GSS), and executive information systems (EIS) (Martinsons & Davison, 2007). DSS are especially useful in complicated scenarios where decision-makers must assess data from various sources.

AECOM as well has long valued data-driven, metric-based decision-making. Their Maintenance Management System called MMS, stores a lot of data comprising site work orders and network assets on a daily basis. The work's breadth produces a plethora of data. The key to every enterprise's success is figuring out how to integrate the massive amounts of data moving within and across business processes together and make sense of them. Data-driven decision-making needs converting data into information, then knowledge, and making decisions afterwards. This is a complicated process, and AECOM has been using Excel tools as a DSS and has largely relied on manual data transformation and analysis by experts.

Current data-to-decision processes have some challenges. Among them is the dependence of data analysis on an expert who knows the business by heart, the request-based nature of the analysis, which means for every information requested by the management, a separate analysis should be conducted by the expert, and the fact that it is very time-consuming, with some investigations taking months to complete. This means that in some instances, the data is already obsolete by the time the analysis is done. Also, there are a large amount of data being captured that is not being put to use in decision-making, and also, there are possibilities for new data to be charged that is not already captured.

Investigations show that Business Intelligence (BI) dashboards are only used within AECOM for reporting to the client. This study proposes BI and BI dashboards also be used for decision-making. In this research, Business intelligence dashboards were introduced as the successor to the DSS to aid with decision-making difficulties within enterprise facility management. BI is a process and a product. BI is a data-driven DSS that incorporates data gathering, storage, administration, and analysis to aid decision-making (Jourdan et al., 2008). Dashboards are single-screen user interfaces with static structures that display information via indicators. A dashboard helps managers and executives access data from different departments in a similar format. Dashboard design and functionality differ per business application (Golfarelli, Rizzi, Formula, et al., 2004).

This study's objective is to determine if the use of BI dashboards in the facility management of filling stations can yield the anticipated advantages. In order to accomplish this, a number of research questions and sub-questions have been formulated. The main question this research seeks to answer is as follows:

**“Can BI utilisation through designed-for-purpose dashboards bring value to the strategic decision-making process within enterprise facility management?”**

To answer this question, a case study within the Facility Management Contract (FMC) team of AECOM Netherlands and a literature review was conducted. The main research methods used were Interviews and Observations. In the end, a pilot BI dashboard was designed, and then the project managers within AECOM were asked to test it.

Literature findings show that BI benefits for businesses include lower costs, greater revenue, improved company performance, and better decision-making (Lönnqvist & Pirttimäki, 2006). Many businesses, however, struggle to maintain their BI system since it is sophisticated and requires continual monitoring (Davenport, 2012). Several examples of application BI tools in Facility Management (FM) decision-making are also offered. They all showed advancements in the decision-making process.

According to the findings of the interviews, the ultimate goal behind decisions is ***business continuity and growth***. Three operation categories, sometimes known as operation pillars, can reflect business continuity and growth. These categories are Finance, Quality, and Safety. Any improvement in these pillars would help the overall goal. The decisions may be categorised based on which pillar they want to improve.

Another way to categorize decisions is by their intended audience. The findings of this study showed that the decisions might be divided into two categories: **Assets** and **Individuals**. Decisions on assets include asset type, brand, model, and replacement date or location. Contractual agreements such as supplier selection, reimbursement form, and training program decisions are examples of people-related decisions. Combining pillars and target groups yields a total of six unique decision types. However, a single choice can be assigned to many decision groups.

The interviews indicated that decision-making performance could be measured using two important indicators: **Time** and **Results**. In this context, decision-making time refers to the time necessary for the decision maker to collect and analyze sufficient facts to reach a judgment. This does not include the time it takes for the decision to be recognized or implemented by the authorities. Changes in the operation pillars previously mentioned can be utilized to quantify the results. The best decision between two equivalent possibilities is the one that results in a bigger rise in finances, quality, and safety while taking less time. A weighted criteria comparison may be used to make a comparison, in which each indication is assigned a weight, and a scale is provided for each category.

The respondents stated that they expect the dashboard to be trustworthy, straightforward, functional, future-proof, encompassing (connecting different sectors of the firm together to reduce duplication of effort), and visually appealing, able to cover a significant amount of data with simple visuals.

According to the findings, using the dashboard saves time. It is done by reducing the need for several meetings throughout multi-year planning to synchronize information from multiple team members. BI dashboards also make information easier to obtain by offering a single point of contact for all users. There is no need to constantly seek data from the data team or other departments. It is stated that the dashboard only saves time if it is trustworthy. Otherwise, users must double-check the data to ensure its accuracy. The practice of cross-checking may nullify the benefit of saving time.

According to the results of the post-experiment survey, utilizing this dashboard is only effective if users are educated to make data-driven decisions based on the information supplied. This is known as information relevance, and it is critical for customers to comprehend how the information supplied to them will influence their decisions. Furthermore, the data source must be trustworthy. Also, dashboards could not totally replace site visits in terms of safety. As a result, they may not give the expected value. The dashboard has the benefit of informing clients by providing safety benchmarks, allowing them to detect problematic places and make further decisions.

All of the project managers who reviewed the dashboard agreed that it might help reduce the Total Cost of Ownership (TCO). Using business intelligence to make data-driven facility management decisions improves investment decisions

on asset replacement plans, reducing the need for emergency repairs. When you stop spending money on short-term fixes, your overall cost of ownership will decrease. OPEX will be reduced by properly identifying CAPEX investment areas utilizing BI dashboards, resulting in a lower TCO. The usage of BI dashboards does not increase the company's transparency, which is already high, but rather facilitates it by making it easier for customers to prepare reports and by providing a single source of truth. Because the dashboard lacked any built-in prediction tools or extrapolations, it was up to the user to develop forecasts by analysing the trends. As a result, not all PMs will benefit fully from it. The reaction timeframes of the site owner and contractor have an impact on asset downtime. The asset breakdown is also presented. Fewer breakdowns equal less downtime (with a minimum of zero hours when no assets fail). Operational decisions are not made using the trial BI dashboard. It cannot help with the fundamental cause of downtime; therefore, using it after an asset fails would not speed up the repair. This dashboard helps to reduce the frequency of repairs by identifying assets that are prone to failure based on their age or work order trend. In general, the survey findings showed that the dashboard met user expectations, and respondents said they would use it again in the future.

Finally, this study shows that implementing BI dashboards may be a feasible option for EFMs to enhance business continuity and development by reducing decision-making time and improving decision outcomes in the areas of finance, quality, and safety. However, in order to properly deploy BI dashboards, the essential BI installation steps must be followed. The findings suggest that having a dashboard available without sufficient training on how to make data-driven decisions with the data provided is rarely effective. Furthermore, the dashboard's validity is related to the accuracy of the data it receives. For a dashboard to be legitimate, the source from which it is drawn must also be valid. Furthermore, it should be recalled that business intelligence is a cycle, and for the cycle to work properly, choices must be constantly identified, as well as data collected and processed depending on those decisions.

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# Glossary

| | |
|---|---|
| **AI** | Asset Integrity / Artificial intelligence |
| **ASAP** | As soon as possible |
| **BAM** | Business activity monitoring |
| **BCG** | Business performance measurement |
| **BE** | Belgium |
| **BI** | Business Intelligence |
| **BMI** | Business Model Innovation |
| **BPM** | Business performance measurement |
| **BV** | Besloten vennootschap |
| **CAPEX** | Capital Expenditures |
| **CCTV** | Closed-circuit television |
| **CDMA** | Code Division Multiple Access |
| **CEI** | Critical equipment inspections |
| **CM** | Care and Maintain |
| **COTS** | Commercial Off-the-Shelf |
| **CRM** | Customer Relationship Management |
| **CSF** | Critical Success Factors |
| **DAX** | Data Analysis Expressions |
| **DM** | Decision-making |
| **DSS** | decision support systems |
| **EAMO** | Engineering asset management organizations |
| **EDW** | Enterprise data warehouse |
| **EFM** | Enterprise facility management |
| **EIS** | Executive Information System |
| **EPCM** | Engineering, Procurement, Construction and management |

| | |
|---|---|
| **ERP** | Enterprise Resource Planning |
| **ETL** | Extraction, transformation, and loading |
| **EV** | Electric Vehicle |
| **FM** | Facility management |
| **FMC** | Facility management Contract |
| **GIDS** | Global Innovation & Design Standards |
| **GIS** | Geographic Information Systems |
| **GSS** | Group support systems |
| **HSSE** | Health Safety Security and Environment |
| **HVAC** | Heating, ventilation and air-conditioning |
| **IBM** | International Business Machines |
| **ICIS** | International Conference on Information Systems |
| **IS** | Information systems |
| **ISO** | Organisation internationale de normalisation |
| **IT** | Information technology |
| **KMS** | Knowledge Management System |
| **KPI** | Key performance indicator |
| **LE** | Latest estimate |
| **LNG** | Liquefied Natural Gas |
| **LSRV** | life-saving rule violations |
| **MIS** | Management Information Systems |
| **MMS** | maintenance management system |
| **NL** | The Netherlands |
| **NMPI** | Near Miss / Potential Incidents |
| **OLAP** | multidimensional/online analytical processing |
| **OPEX** | Operational expenditures |
| **PC** | Personal Computer |
| **PLS** | Partial Least Square |
| **PM** | Project manager |
| **RBV** | Resource-Based View |
| **RVI** | Retail Visual Identities |
| **SLA** | Service level agreement |
| **SME** | Small-to-medium enterprise |
| **SQL** | Structured Query Language |
| **SST** | Sense-seize-transform |
| **TCO** | Total cost of ownership |
| **TPS** | Transactional Processing Systems |
| **URL** | Uniform Resource Locator |

# 1 Introduction

This part offers background information on the facility management of gas stations and the associated issues, followed by an explanation of the need for decision support systems in this setting. The article then describes the latest trends in decision support systems to give an understanding of the industry situation and possible solutions to the upcoming challenges. Finally, current issues and the research's objective will be presented.

## 1.1 Setting The Stage

In 1920, Zeist established the Netherlands' first gas station, called a street pump at the time. It was a Shell pump at the opulent de Pabst hotel. Belgium's first street pump was installed in 1922. Petrol stations were also established beside roadways beginning in 1927. This was also important as the number of automobiles in the Netherlands increased from 11,000 to 100,000 between 1920 and 1940 ("Gooi Maar Vol," 1993).

In 2021, the total number of gas stations in the Netherlands had reached 4,147, including uncrewed stations. In the Netherlands, Shell is the dominant fuel station brand. As of June 2021, the British-Dutch oil and gas conglomerate had branded 413 gas and petrol outlets around the nation, not including express fuel stations (*Netherlands: Number of Fuel Stations 2021 | Statista*, n.d.).

The cumulative annual growth rate of combined gasoline and diesel sales for the previous decade has been roughly 1%. Due to the strong correlation between economic growth, vehicle sales growth, and demand for liquid fuels, the industry is unlikely to have considerable organic growth in the near to medium term. Due to the slow growth rate and the tightening of pricing control, gasoline merchants increasingly depend on convenience shopping, fast food, loyalty partners, and a more appealing purchasing experience to bring people to their forecourt. To add to the complexity, new ownership and procurement requirements are compelling retailers to thoroughly analyse every supplier and partner in their ecosystem for compliance and support (Pragma, n.d.)

The increased station count, combined with the provision of new services, has increased the total diversity and the number of assets per petrol station, hereafter called "station" or "site". Several contractors and suppliers do the maintenance job called "the tasks" based on the asset being maintained; thus, maintaining the security and reliability of these assets has become increasingly complex. Asset managers are confronted with an onslaught of data, making it harder to make effective investment decisions (Personal communication, Feb 2022). A schematic of a typical station can be found in the pictures Figure 1.1 and Figure 1.2.

The typical facilities in a station include the following:

1. Containerised substation
2. EV architecture & scenarios
3. Car Wash
4. Service Bay
5. Buildings & Building Services
6. Forecourt Services
7. Solar roof
8. Solar Panels
9. Canopy & RVI
10. Sales Building
11. Dispenser
12. Fuel Installations
13. EV Substation equipment
14. Fuel systems & Alternative fuels


**Figure 1.1 Facilities within a typical station, Gids.shell.com (2022)**

## 1.2 Strategic decision-making and support systems

Decision-making is a fundamental activity for managers. It is “the essence of the manager’s work” and “a fundamental component of organisational life.” (Robbins, 1991) and (Robbins, 2000). Management of filling stations is not an exception, and facility managers must make strategic decisions daily. In doing so, the managers are confronted with many challenges, including the overload of data and the biases in the manager’s conception, making them imperfectly rational (Molloy & Schwenk, 1995).

Due to the limitations of human cognition and information processing concerning the complexity of the challenges confronting individuals and organizations, rational conduct necessitates simplified models that capture the essential characteristics of a situation without capturing all of its complications (March & Simon, 1993).

A significant study has been conducted to investigate how strategic decision-making might be improved. Researchers have devised a variety of structured decision aids to assist managers in identifying and overcoming human decision-making shortcomings. Many have lauded information technology as a decision aid with tremendous promise for increasing the efficiency and efficacy of strategic decision-making (Molloy & Schwenk, 1995).

Numerous computer-based information systems (IS) have been created to aid in decision-making, including decision support systems (DSS), group support systems (GSS), and executive information systems (EIS) (Martinsons & Davison, 2007). DSS are especially useful in complicated scenarios where decision-makers must assess data from various sources. Executive Information Systems (EIS) are designed with executives in mind. They have been used to monitor and communicate company performance data and to scan the business environment (Ba et al., 1997; Elam & Leidner, 1995). A GSS consists of software tools that are intended to concentrate and structure group deliberation, hence lowering the cognitive costs associated with communication while group members collaborate to accomplish a goal (Davison, 2001).

This study focuses on the applications of Business Intelligence (BI) as a successor to decision support systems. One of the key characteristics of Today’s BI systems is their inclusion of a BI dashboard. Dashboards are supposed to improve decision-making by enhancing cognition and leveraging perceptive human talents. As a result, interest in dashboards has risen recently, as seen by the market’s growth of dashboard solution suppliers(Yigitbasioglu & Velcu, 2012). When specific visualization concepts and characteristics are present, dashboards are more likely to succeed and overcome difficulties with display format and information load (e.g., high data-ink ratio and drill-down features) (Yigitbasioglu & Velcu, 2012).

It is well known that the creation of a useful dashboard requires the execution of a cycle starting from data collection and ending with data-driven decision-making using the appropriate visuals. This cycle is known as the intelligence cycle, and the next section will elaborate on BI, and the cycle mentioned furthermore.

## 1.3 Business Intelligence And BI Dashboards

Business intelligence systems are instances of data-driven DSS. A data-driven DSS enables access to and manipulation of massive structured data databases, particularly time series of internal and external enterprise data (Power, 2002). BI is occasionally used synonymously with Online Analytical Processing (OLAP) and other DSS-related terms. BI is a popularised umbrella word coined in 1989 by Howard Dresner of the Gartner Group to refer to a collection of concepts and approaches for enhancing corporate decision-making via the use of fact-based support systems. Often, "business intelligence" software is used to query a database and generate reports (Power, 2002). Figure 1.3 shows the evolution of DSS concepts in the timeline between the 1960s to 1990s.

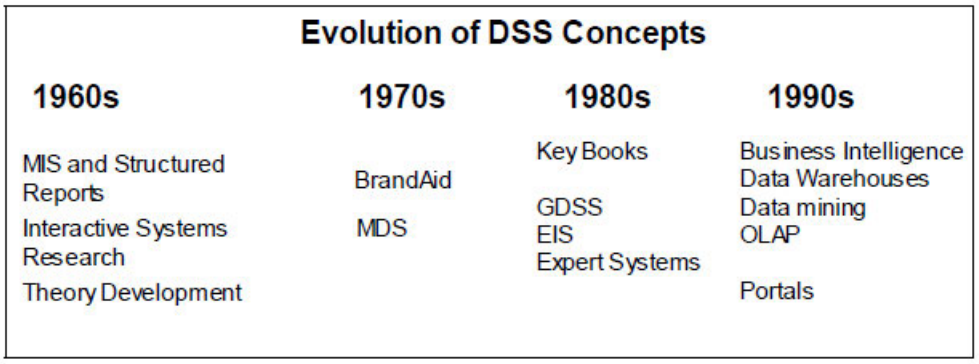


**Figure 1.3 Power, D. (2002). Evolution of DSS Concepts**

BI, which is often known as business analytics, is described by Negash et al. as a discipline that applies data mining techniques to operational data to obtain insights for management decision-king (Negash & Gray, 2008). It is apparent from many definitions given that a big part of BI benefits from data. As mentioned by (Golfarelli, Rizzi, & Cella, 2004), BI is used to turn data into knowledge, which is then used to make a strategic decision. McKinsey&Company (2011), BCG (2013), and numerous other studies suggest that firms will need to be able to interpret huge data volumes in order to prosper.

The importance of data management and data-driven decision-making has been known to companies for quite a while. BI constitutes the highest single spend by companies across all IT expenditures since 2009 (Kappelman et al., 2017). There are also many companies that offer BI applications for commercial use; Among those, it can be named Microsoft Power BI, Zoho, and Christiansteven.

BI Dashboards

Business intelligence dashboards are data analysis tools that combine information management and visualisation. Content developers may mix charts, graphs, and reports on a single page for snapshot overviews by utilizing interactive features such as filters and actions. Dashboards are a common feature of business intelligence systems because they offer simply understood data analysis, allow you to select which information you examine, and enable you to share your research's conclusions with others.

Dashboards are critical components of a corporation's business intelligence strategy. They should be purpose-built and constructed specifically for the goal of analysing data from critical datasets in order to enhance business decisions. Rather than having analysts manually compile spreadsheets, current business intelligence tools enable analysts to access, analyse, visualize, and share data using web-based dashboards. Stakeholders may create dashboards to examine, make conclusions, and act using a sophisticated, automated business information platform. (tableau, 2021)

## 1.4 Problem Overview And Research Gap

Facility owners, manufacturers, and contractors of performing construction systems have identified a need for a new design, procurement, and construction delivery system that integrates performance data in order to deliver the "best available" performing contractors and installed systems at the most cost-effective price (Kashiwagi & Moor, 1995). Firms have understood the importance of enforcing the achievement of the goals defined by their strategy through metrics-driven management (Ranjan, 2008).

Initial exploratory interviews with facility managers show that they have as well identified the importance of performance data both from the assets as well as the suppliers in enabling strategic decision-making. For example, in 2019, AECOM, which is an engineering consultancy firm in charge of facility management of filling stations, established a maintenance management system (MMS) in collaboration with Urgent technologies, which collects a variety of data regarding every work order that undergoes within the system (Personal communication, Feb 2022). The extent of the network and the abundance of the assets have resulted in an extensive repository of data.

Data collection is only one of the several steps required to achieve business intelligence. Additional information is not always advantageous to the organization, as the organization's capacity for processing information and knowledge is also limited (Simsek, 2009). As a result, organizations need to construct information filters and procedures to deal with the constraints of constrained rationality (March & Simon, 1993; Nelson & Winter, 1982).

The key to every enterprise's success is figuring out how to integrate the massive amounts of data moving within and across business processes together and make sense of them. Extraction, transformation, and loading (ETL), data warehousing, database query and reporting, multidimensional/online analytical processing (OLAP) data analysis, data mining, and visualization are all examples of business intelligence, which can be considered one the general solutions to large data integration(Ranjan, 2008).

Dr Lourival Carmo Monaco Neto has depicted the transformation of data into intelligence in the following picture (Figure 1.4). It can be seen that the data should be first turned into information by connecting different parts of data together with the inclusion of context. When information is joined with experience and intuition, knowledge is formed. (Surbhi, 2018)

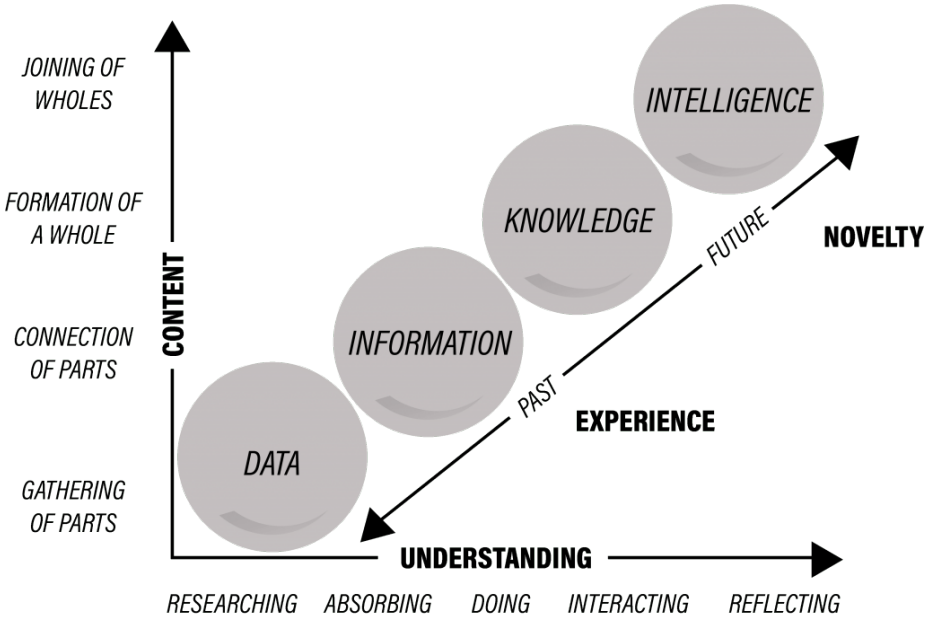


Figure 1.4 Monaco Neto, Transformation of data into intelligence, retrieved from agribusiness.purdue.edu

Intelligence is obtained through the process of effectively presenting data analytics results to decision-makers in order to aid decision-making (see Figure 1.5). Larry Kahaner writes in his book "Competitive Intelligence" that after data and information have been properly examined and the results aggregated, it is time to disseminate the findings to those who posed the questions. This is a vital stage in the intelligence process, and many companies fail at it. (Kahaner, 1997)

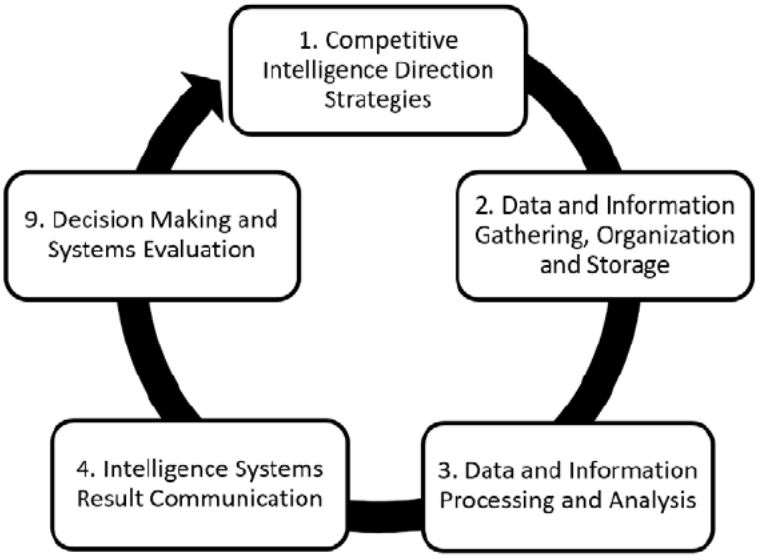


**Figure 1.5 Monaco Neto, the intelligence cycle, retrieved from agribusiness.purdue.edu**

Business Intelligence is not a niche subject within facility management companies and consultancy firms, although there might be employees that are not familiar with that term in particular or to know an appropriate definition of it. For instance, exploratory investigations within the AECOM ecosystem and observations show that there are already indications of business intelligence in place within the company. That is due to the presence of a "power BI" dashboard embedded within the MMS ecosystem that is used by AECOM (see Figure 1.6).

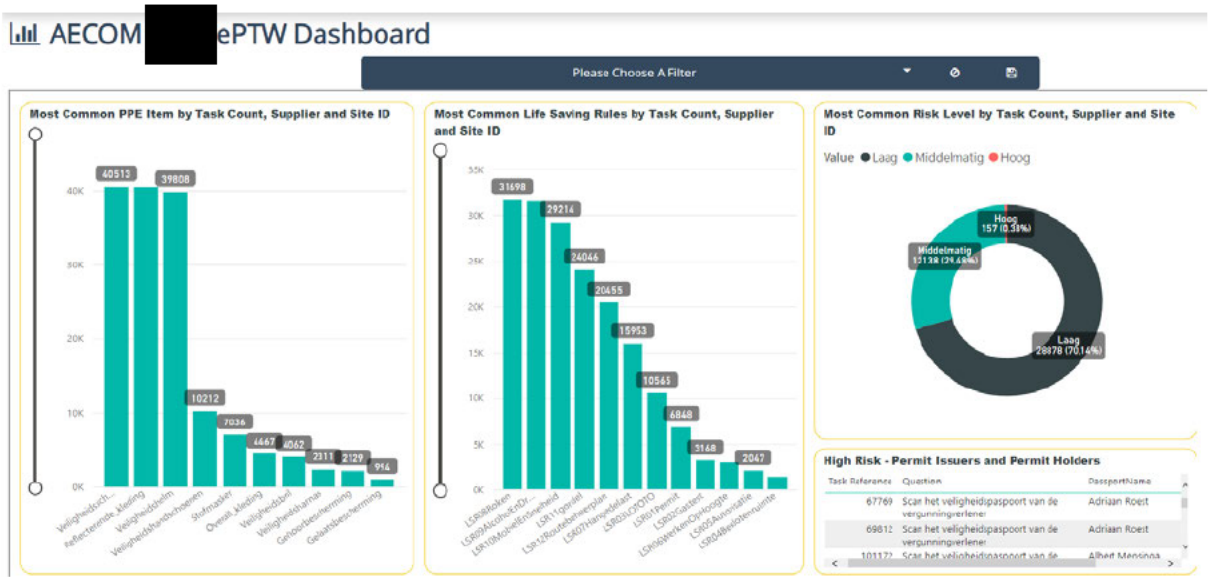


**Figure 1.6 Example of BI dashboard already in place within MMS system**

However, the current BI dashboards are mostly operational or used for reporting to the client and are not used or have a minimum use by program directors, project managers and maintenance leads within AECOM as a decision

support system. In other words, strategic decision-making, such as investment decisions, is not impacted by the current BI dashboard (G. Interview participant, personal communication, Jan 2022). On the other hand, data-driven decisions are indeed made within the company, but the process of reaching decisions from data does not follow a properly defined managerial decision-making model based on a purpose-made DSS. For example, deep-dive data analysis is done manually by a knowledgeable data analyst who has a good overview of the system, using mostly common software such as Microsoft excel. This process is done on-demand, in which the analyst would extract the relevant data from MMS into excel sheets, apply appropriate filters based on his own knowledge, create pivot tables, and then obtain the necessary visuals that can be used by management in their decision-making. This process can take up to months (The Interview participant and Interview participant, personal communications, Jan 2022), by which the data have become already obsolete, resulting in less reliable results.

Observations point out the roots of this problem to be the presence of different blocks of the intelligence cycle happening within the company separately, but the absence of a connection between them and thus, not forming a complete intelligence cycle. This is due to the lack of a proper business intelligence platform dedicated to strategic decision-making and the unfamiliarity of decision-makers with newer software. A one-to-one mapping of the current AECOM data-driven decision-making process to the cycle shown in Figure 1.5 demonstrate that 1- The management has intentions of improving data handling within the company to improve decision-making, as seen by AECOM's recent initials to enhance the current BI dashboards 2- The data gathering and organisation is being done by MMS system, and there is an ongoing process to build up an SQL database 3- Data processing and analysis is done partly within MMS and partly manually using Excel by a business analyst. 4- Result communication can be done using BI dashboards but is currently majorly done using excel graphs and PowerPoint presentations. 5- Not all the data collected is used in decision-making, and not all decisions are data-driven, but there have been data-driven decisions based on the finding of data analysis in the past (Interview participant, personal communications, Jan 2022).

There has been extensive research on the application of information systems in decision-making; for example, (Molloy & Schwenk, 1995) determined the influence of information technology on the various phases of the decision-making process through a thorough examination of ways in which information technology enhances decision-making efficiency and effectiveness at each step of the strategic decision-making process. Geng & Wang, 2022; Giordano et al., 2022; Ma et al., 2020; Manco et al., 2022; Mohammadi et al., 2021; Pinjala et al., 2006 have specifically examined the application of data analysis and decision support systems in the maintenance. For example, (Manco et al., 2022) present a model that may be used to assist decision-makers in selecting a daily maintenance approach for geographically scattered assets. It demonstrates that balancing opportunistic and preventative maintenance actions and appropriately setting the model's thresholds makes it feasible to lower the overall maintenance cost and the total number of sites visited each year.

Few papers focus on BI as a successor to decision support systems and its applications in maintenance management. To name a few, (Barycki, 2020) studied the application of BI in the recommendation-making process of waterways connections and tried to determine if some parts of suggestion-making for asset management in water corporations may be assisted by the use of widely accessible and deployable business intelligence technologies. (Tanphet & Wanchai, 2018) used business intelligence (BI) technologies to schedule maintenance and repair of equipment. The multidimensional data model was created as a star schema for the purpose of doing multidimensional analysis, ad hoc analytics, and online analytical processing. The findings indicated that implementing BI benefited executives by providing a variety of data points that could be used for more suitable and timely decision-making and strategic planning. (Head et al., 2010) It discussed the advantages of utilising Commercial Off-the-Shelf (COTS) business intelligence software to assist aviation and automated test system maintenance settings.

As no academic studies that specifically focused on the BI applications in facility management of filling stations could be found, there is a need for research which focuses on the applications of BI in the mentioned environments so that the usefulness of this proposal can be determined in dealing with the aforementioned problems. The results of this study can help come up with recommendations on how to benefit from BI in EFM.

## 1.5 Goal Of Study

This study's objective is to determine if the use of BI dashboards in the facility management of filling stations can yield the anticipated advantages. In order to accomplish this, a case study will be undertaken, and a number of research questions and sub-questions will be formulated.

The selection of a case study helps to provide access to data and expert knowledge within the company. The case selected has fundamentals of BI in place which can greatly help the process. To reach the intended goal of this research, this study tries to answer the following research question:

**"Can BI utilisation through designed-for-purpose dashboards bring value to the strategic decision-making process within enterprise facility management?"**

This question indicates that BI is proposed as a solution to the problems stated in the problem description. This proposal will be evaluated by measuring how much value has a pilot dashboard to the company in their decision-making in a specific domain. This domain will be selected after answering some of the initial research sub-questions. To help answer the main research question, the following sub-questions have been formulated:

1- What is the state of the literature on the topic of data-driven decision-making using BI with a focus on EFM?

2- What are the top strategic decisions in EFM regarding filling stations at the management level, and what is the decision-making procedure within AECOM?

An answer to this question is necessary for setting the north in this study. One of the fundamental differences between this study and other similar studies is the focus on filling stations. Management of filling stations is different from other forms of EAMM in terms of decisions that need to be made therein. It also helps to familiarise with the process of decision-making, from the need emergence to the final decision-making of the manager. This is useful for identifying the requirements of the dashboards based on which part of the decision-making procedure it is being used for.

3- What input is required in making the identified decisions in EFM of filling stations?

As shown in Figure 1.5, reaching the decisions identified after answering sub-question 1 requires information and knowledge made from data gathering, filtering and analysis. Identifying this input is key in implementing business intelligence.

4- What indicators can be used to evaluate A. These strategic decisions and B. The decision-making process in EFM of filling stations?

This is a vital stage in this study as it is necessary to measure the effects of the change before and after BI utilisation. This way, by comparing the numbers, we can see how much decision-making improved after BI implementation.

5- What are the expectations of BI dashboards from the facility managers of filling stations?

This question helps when designing a pilot BI dashboard. This way, when a test dashboard is made and evaluated, we can conclude that the results are indications of BI utilisation and they are not negatively affected because of a poorly designed interface.

6- How has decision-making within EFM of filling stations improved based on the identified indicators after using the pilot designed for the purpose BI dashboard?

This question relates to a comparison between the data collected during the tests and directly contributes to the answer to the main research question.

## 1.6 Expected Results

By identifying and classifying the decisions made at the strategic level, as well as by identifying the input required for data-driven decision-making within this domain, the findings of this study are meant to shed light on the topic of decision-making within the facility management of filling stations. Additionally, the model that will be developed to measure the impact of BI on decision-making at a strategic level can also be used to evaluate the impact of other decision support systems. Last but not least, an AECOM-specific dashboard that will be tested by facility managers will be designed and developed based on the needs that have been identified. The findings of the evaluation may be put to use to either justify the implementation of the BI dashboard within FM organizations, particularly in negotiations with the client or to prevent unnecessary expenditures on the development of dashboards. In the former case, the results may be put to use to justify the implementation of the BI dashboard.

## 1.7 Structure

The second chapter provides a comprehensive discussion of the research's background. This comprises an introduction to the AECOM case study and its relationship to the subject of this research. In the third chapter, the components involved in the research design are described, and the research methods used in this study are explained. The fourth chapter answers RQ1 and provides an extensive literature review on subjects of decision-making and the use of information systems. A separate sub-chapter focuses on applications of BI and IS in EFM. In the fifth chapter, the information gained from the literature review will be put to use to lay out the interview setup. In this chapter, the process of conducting the interviews, including the interviewees, format and content, will be introduced. Chapter six will provide the results from analysing the interviews. Aside from information about decision-making within facility management which answers RQ2 and RQ3, in this chapter, the expectations from a BI dashboard and also the possibilities for a specific case will be considered (RQ4 and 5). In Chapter seven, using the information from the last chapter, the process of creating a tailor-made dashboard will be explained, and different off-the-shelf BI tools will be introduced. Also, the data model used in the pilot dashboard and the design of the interface will also be described. In chapter eight, the results of testing the pilot dashboard by the PMs will be provided (RQ6). Finally, in the last chapter, answers to the main research questions will be elaborated on, and discussions on this article will be made.

# 2 Case study: AECOM

AECOM is a U.S.-based engineering consultancy firm with many offices all around the globe. They are active in many markets such as energy, transportation, healthcare, water and so forth. In the Netherlands, They have been actively working under different contracts with “the client”, which is one of the biggest oil and gas companies in the Netherlands. The client is active in several different sectors of energy production, generalizing into upstream and downstream. On the downstream side, they own numerous filling stations around the world. In the Netherlands, this number is about 413, excluding the unmanned stations. Currently, The client has two major contracts with AECOM: 1- Engineering, procurement, construction and management contract (EPCM) and 2- Facility management contract (FMC).

EPCM is concerned with the design and construction of new stations or the upgrading of the current stations. Thus, the EPCM budget is considered CAPEX. It can be said that the EPCM is related to the expansion of the business.

FMC, on the other hand, is considered to maintain the current assets of The client. This contract is broken down into two parts: 1- the maintenance program and 2- the care and maintenance and asset integrity program (CM/AI). The first part is concerned with reactive and proactive maintenance of the client assets within the stations. Hence, most of the expenditure within this section is OPEX. CM/AI, on the other hand, deals with the timely replacement of older assets or the replacement of those assets that cannot be repaired anymore. Although the CM/AI expenditures are CAPEX, they can be distinguished from the EPCM expenditures in the way that CM/AI only includes the current assets, while EPCM focuses on the addition of new ones. In Figure 2.1 contractual relations, a schematic of the two different contracts can be seen. As it can be seen in the figure, AECOM has a managing role in this stance, organizing the work for several other suppliers, contractors and subcontractors. In this organization, The client is considered the first Layer (L1), while AECOM and the real estate managing company and other similar companies are L2, and Suppliers are L3. If the contractors are also sub-contracting a part of their work, the sub-contractors are called L4.

The contractual relation between The client and the sites are also various. Usually, The client is not the owner of the land but owns the facilities installed. In some other cases, the client franchises the brand meaning it is not the owner of the facilities nor the land but only responsible for delivering the fuel and limited maintenance. In the latter, AECOM is also not responsible for the site.

The client has selected AECOM to provide retail facility management services (L2) in the Netherlands and Belgium (LNG only). This involves the planning, coordination, management, administration, and auditing of all planned, preventative, and permitted reactive maintenance, repair, and minor capital projects carried out within the program's network. This program now covers Facility Management Services for the Netherlands' Retail Network Sites LNG for the Netherlands (NL) and Belgium (BE).

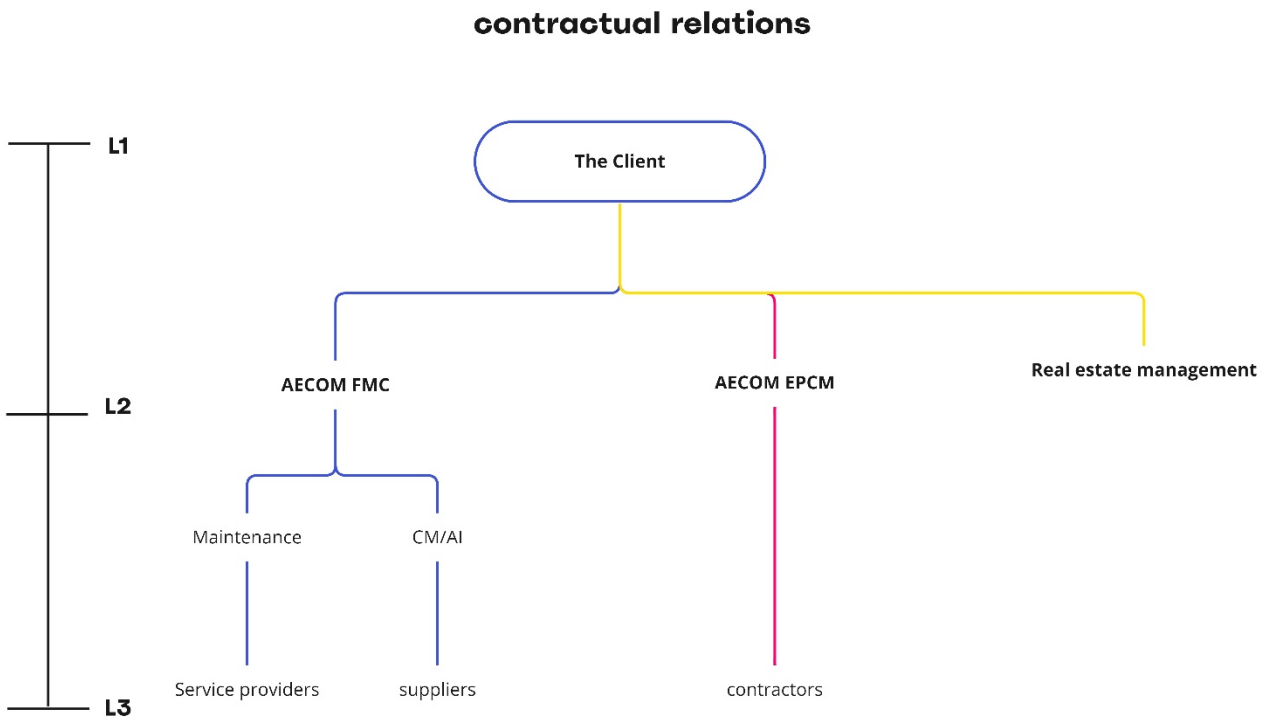


**Figure 2.1 contractual relations**

In the Netherlands, FM Retail Services covers around 350 locations. The most current number of locations may be seen on The client outlet list, which is updated monthly by the client as locations are added and removed from the Network on a regular basis.

In addition to the FM Retail Services Contract, NL AECOM is responsible for the future LNG fueling stations. The number of LNG terminals in Newfoundland and Labrador was initially seven but is likely to grow as other terminals come online. In BE, the first LNG facility debuted in 2018, and this number is expected to grow as further facilities come online. As the development of future fuels advances, maintenance will encompass these services as well, such as electric vehicles.

To ensure that AECOM's contractual obligations are met and, where feasible exceeded, the FMC Team should acquire and supervise contractors to perform service maintenance tasks across the program. By managing and coordinating the expertise acquired in civil and structural engineering, soil and groundwater engineering, building services engineering, and fuel technology, including LNG, the FMC team will manage planned and unplanned maintenance activities that will adhere to The client Network Imperative (Table 1)

AECOM will be responsible for leading, developing, assuring, and coaching the L3 contractors in order to ensure compliance and promote continuous improvement that benefits stakeholders and is consistent with The client's objectives.

**Table 1 Network Imperatives to the Retail Engineering activities (Source GIDS 00.004)**

| NI, comply to | Control Points |
|---|---|
| 1 HSSE, Contractor Safety | Compliance to the Contractor safety Manual and related with Shell HSSE & SP Control Framework requirments. |
| 2 Global Design Standards & RBSAM (Includes GFAs) | Compliance with the Global Design Standards (with their mandatory components on HSSE, Brand & RBSAM) |
| 3 Eng Project Management System & Assurance | Compliance to the Engineering Assurance requirements including the E2E processes |
| 4 Contract Management Plan, CMCP | All Contract Holders and Owners comply with the CMCP process, roles and responsibilities. The Procurement Management Plan is in place. |
| 5 Group Record | Retention and filing of permits, L3 contracts, engineering and project documents as per Group Records Management requirements. |
| 6 Asset Register | Ensure Accuracy of the Asset Ledger |
| 7 ABC | Compliance with local and international laws prohibiting bribery and corruption |

AECOM provides comprehensive planning, coordination, management, administration, and auditing service for all legal, scheduled, preventative, and authorized reactive maintenance repair work, as well as modest capital, works. On request, AECOM may also supply other projects that meet the client's safety and environment, duration, target cost, and quality standards for the Company's retail network.

The FMC's scope of work includes the following:

- Assurance of HSSE and compliance with legal and GIDS requirements
- Management of health, safety and environment, and security
- On-the-spot inspections of the works
- NMPIs and incident investigation
- Management of Disasters
- Maintenance Management System End-to-End (E2E) for FMC
- Handover of the site and integration with the EPCM
- Maintain and update the asset database
- Post-Construction Damage Management
- Management of calls and WOs
- Delivery of value via a maintenance management system
- Management of inspections, legal, and CEI compliance
- Planning for Business Continuity
- Multi-Year-Planning
- Cost-cutting initiatives/optimization of the total cost of ownership/e2e assurance
- Management of Finance
- Reimbursement of L3s
- Estimates, risks, and other information about LE each month Reporting
- Sourcing and managing Level 2 partners and Level 3 /4 contractors that fall within the scope
- Delivery of value
- Accreditation of Contractors in Planning

# 3 Research Design

The book research design: qualitative, quantitative and mixed methods (Creswell, 2003) describes three components involved in research design: 1- Philosophical worldviews, 2- Selected strategies of inquiries and 3- research methods. These components are interrelated, and the selection of one affects the selection of the others. This study is designed based on selecting those components. In doing so, first, the worldview that best matches the mentality in this research is selected.

## 3.1 Paradigm

The worldviews or "paradigms", as called by some other authors (Lincoln and Guba, 2000), are a "basic set of beliefs that guide actions." There are four paradigms introduced by Creswell: Post positivism, Constructivism, Advocacy, and Pragmatism. As this study is on the management domain and involves personal views and data in the form of written arguments as well as data analysis and possible quantification of the results, it has focused on world views that best match the qualitative or mixed strategies of inquiry. This reduced the perspective on paradigms to one of advocacy and pragmatism. While the advocacy worldview is change-oriented and addresses political issues through the lens of marginalised people (in contrast to post-positivism), the pragmatic worldview is problem-centred, pluralistic, and grounded in real-world experience. The latter perspective is concerned with applications and resolutions. Due to the fact that this study is centred on the challenges and demands of AECOM and is also problem-oriented, the pragmatic view has been chosen for this study.

## 3.2 Strategy Of Inquiry

Strategies of inquiry are the types of qualitative, quantitative or mixed methods designs or models that provide specific direction for procedures in a research design (Creswell, 2003). In Table 2 Alternative strategies of Inquiry, J. Creswell, Research design (2003), Creswell provided an overview of strategies of inquiries based on the type of the research data collection.

In this study, as mentioned earlier in this chapter as well, the Qualitative strategy of a Case study is used. Case studies are in-depth examinations of a program, event, activity process, or one or more individuals by the researcher. Case studies are defined by time and activity, and researchers collect detailed information over an extended period of time utilising a range of data collection approaches (Stake, 1995). The mentioned data collection approach is determined in subchapter 4.3 Research methods.

**Table 2 Alternative strategies of Inquiry, J. Creswell, Research design (2003)**

| Quantitative | Qualitative | Mixed Methods |
|---|---|---|
| • Experimental designs<br>• No-experimental designs such as surveys | • Case study<br>• Phenomenology<br>• Ethnographies<br>• Grounded theory studies | • Sequential<br>• Concurrent<br>• Transformative |

## 3.3 Research Methods

This section will provide information about the research methods chosen to answer each of the research sub-questions (see **Table 3** research method details for each research question). The term "research methods" refers to the procedures for collecting, analysing, and interpreting data that researchers propose for their investigations (Creswell, 2003). The first step in data collection is conducting a **literature review**. Although Literature review is not a Qualitative research method, it is beneficial to familiarise me further with the topic and find out the previous similar studies on the subject, pointing out the research gap and helping design the research method. The literature review is done in Four different categories:

1- Applications of information systems in decision-making
2- Decision-making within facility management
3- Business Intelligence and dashboards
    a. Definition of Business intelligence and dashboard
    b. History of BI and Dashboard
    c. Components of business intelligence
    d. Role of Analytics
    e. Implementations of Software
    f. Monitoring Dashboards
    g. Guidelines for implementing BI (Checklist)
    h. Advantages of BI and dashboards
4- Applications of business intelligence in facility management

**In-depth interviews, small surveys, participant observation**, and **document studies** are all suitable qualitative tools for post-evaluation case studies. Interviews produce detailed accounts that enable a thorough investigation of what occurred and why (Kelly & Bowe, 2020).

### Interviews

The main source of data collection in this study is semi-structured interviews in which some of the questions are planned in advance in regard to that, but there is a possibility of exploration during the interview to ask more unplanned questions. Methods used during the interview and more information about the interview setup, questions and participants can be found in section 5, Interview Setup.

### Observations

One of the other methods used in this research is a **semi-structured participant or non-participant observation**, in which the author watches, observes and analyses the events of interest (Lambert, 2012). All data gathering methods require observation in some capacity. Observational research methods are a distinct type of data collection apart from interviews and questionnaires. Rather than depending on a subject's self-report replies to questions or comments, the observational method of data collection depends on seeing and hearing things and documenting those observations. One can also observe things with his/her other senses. Observation might be organized, semi-structured, or unstructured. The foundation of a highly organized and methodical observation is meticulous planning. It may also be pre-coordinated, in which case one will determine beforehand what types of images he would seek. In this situation, a hypothesis, issue statement, or problem question has already been developed, so the type of data required is known. Systematically collecting information in picture format necessitates adherence to the strategy, which may include places, time, types of photographs to gather, etc. Structured observation is typically used to obtain qualitative data; however, quantitative data collection is also feasible.

A semi-structured observation will be based on planning, potentially even an agenda or a list of the information required. The method of operation, i.e., the way in which one will search for and gather photographs, may be random,

with the hope that what is searched for will be found. In this situation, there might exist a hypothesis, problem statement, or problem question. However, the act of gathering photographs may prompt a research topic.

An unstructured observation would be one in which it is unclear what type of data is being sought. One will likely operate in an unsystematic manner in this instance, depending on the chance to uncover interesting data. Consequently, a hypothesis, problem statement, or problem question will be developed at this point.

The observer's function is to maintain detachment from the group or process, acting just as an observer. The observer must not take part in the actions but instead observe and document the information (an etic approach). However, it is also feasible to witness from the inside, i.e. as a member of the observed group (an emic approach) (Ostrower, 1998; *Smi-Structured Observation – INtgrty*, n.d.)

This method can be suitable as there is an ongoing endeavour going through the company in which a data team is trying to build up a SQL database that will be used in creating reports. As there is an alignment of interest with this study, the author will be a participant-observer in many of the meetings, especially those with the management within which answers to the RQs are sought after.

## Document study

When designing the BI dashboard to answer RQ6, aside from the findings of the interviews and observations, a document study in the form of AECOM archival data analysis will be performed. Document analysis is frequently used in conjunction with other qualitative research methods as a way of triangulation, which is defined as "the employment of many approaches to examine the same issue" (Denzin, 1970, p. 291). The qualitative researcher is required to utilize various (at least two) sources of evidence, i.e., to seek convergence and corroboration through the use of diverse data sources and methodologies. These sources include interviews, participant or non-participant observation, and tangible artefacts. By triangulating data, the researcher aims to generate a confluence of evidence that nurtures credibility'. The researcher can lessen the influence of any biases that can occur in a single study by corroborating findings across multiple data sets by reviewing information gathered via various approaches. Triangulation protects the researcher against the criticism that the outcomes of a study are the result of a single technique, source, or investigator's bias. (Bowen, 2009)

Document study will help identify the impact of data-driven decisions in the past, showcase how BI could bring benefit to AECOM and also provide the data required for the creation of the dashboard. The data is majorly provided within the MMS system or the new SQL database. Some of the older data is stored digitally in the form of excel, which will be accessed within the AECOM server.

## Post experiment evaluation

After answering the first five research sub-questions, a purpose-made prototype of a BI dashboard can be created. The target group will be asked to validate the interface by using it, and then the second set of interviews will be conducted to determine to what extent they believe the new dashboard has improved their decision-making and validate the findings. The experiment setup and the survey, along with the experiment results, will be further elaborated on in chapter 8 Post experiment survey.

In Table 3, an overview of methods used for each sub-question, along with the expected results and participants, are listed. Because this is a qualitative study, rather than focusing on instrument validity, this study will attempt to ensure the effectiveness of the interview guide and observation approaches.

Table 3 research method details for each research question

| | Method | Expected results | Participants |
|---|---|---|---|
| **Sub question 1** | Literature review | Overview of the current studies over data-driven decision-making using IS in facility management | |
| **Sub question 2** | Semi-structured Interviews/ observation | different decisions such as vendor selection, payment option, asset replacement, scheduling | program director FMC, project manager maintenance, maintenance leads, data analyst and consultant, data team |
| **Sub question 3** | Semi-structured Interviews/ observations | difference performance indicators based on the decision | data analyst AECOM, Urgent BI team, program director and PM |
| **Sub question 4** | Semi-structured Interviews/ observations | decision-making time, value generation, effectiveness | The client corresponding program lead, AECOM country manager, AECOM FMC director |
| **Sub question 5** | Semi-structured Interviews/ observations | visual requirements, level of information diving, information expectation | data team, project controls expert |
| **Sub question 6** | Post experiment evaluation | changes in values of decision-making evaluation indicators | program director FMC, project manager maintenance, data analyst consultant |

## 3.4 Data Gathering and Analysis

Most of the data required will be gathered from AECOM's internal repository, especially from the MMS system. The management of AECOM will be asked about their strategic decisions in the past and their expectations. The current reporting style within the company will be studied. The current BI dashboard will be accessed within MMS.

An asset/supplier will be selected in consultation with the AECOM management, based on which a pilot BI dashboard will be designed. Possible required information can include Asset description, quantity and geographical location, manufacturer, responsible maintenance supplier, breakdown and repair history, maintenance costs and purchase costs. The exact information required will be determined when answering the first three sub-questions.

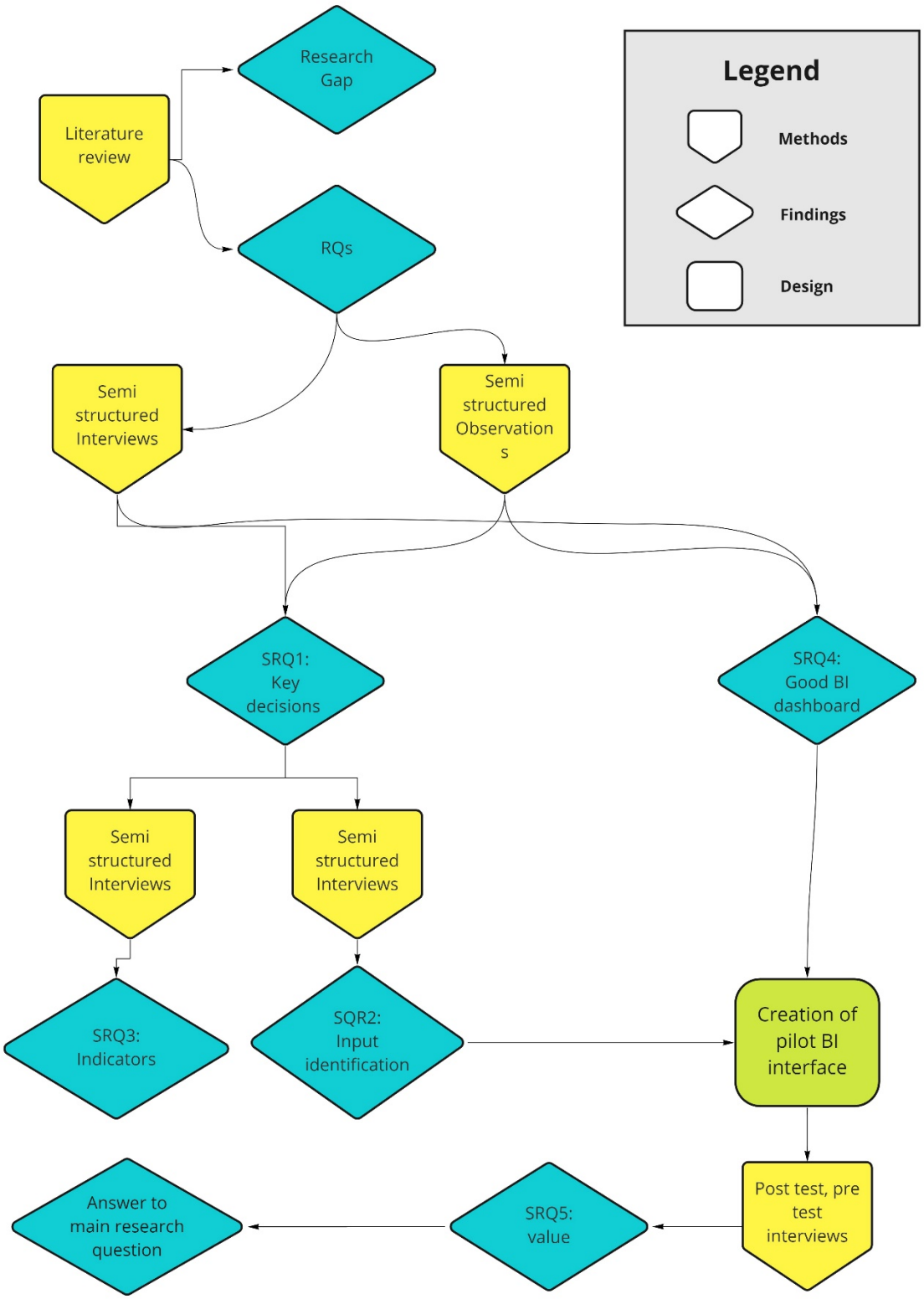


**Figure 3.1 The methodology of research**

# 4 Literature review

This chapter seeks to provide information about the studies that have already been conducted on the subjects of IS in decision-making and also the decision-making within EFM. After that, it will specifically target the applications of BI in the EFM. This chapter will provide an answer to the first research sub-question.

## 4.1 Applications Of Information Systems In Decision-Making

Currently, businesses are in a race to improve their capabilities in order to compete in the global market of the twenty-first century. Therefore, companies are striving to increase their degree of agility by enhancing the decision-making process to be more efficient, speedier, and highly effective in order to respond to market swings and allocate precious resources effectively (Karim, 2011). Moreover, firms involved in many projects concurrently confront different management issues (Elonen & Artto, 2003). In an effort to do this, a number of modern mid- to large-sized firms have engaged in a cycle of progressive investments in and adoption of new management information systems components. During the past two decades, a large proportion of financial institutions have utilized Management Information Systems to facilitate the delivery of services, and the rate of adoption is anticipated to increase as the technology develops. An information system is a collection of organizations, data, procedures, and technology that work together to collect, process, store, and provide the decision-making process with information output (Karim, 2011). IS-unique or somewhat unique bodies of concepts, theories, processes, and application systems are analysed quarterly. He outlines five knowledge bodies that have evolved in the IS tradition (See table Table 4) (Baskerville et al., 2017).

Table 4 Five knowledge bodies that have evolved in the IS tradition, Baskerville et al., 2017

| Bodies of knowledge unique or somewhat unique to Information Systems | Examples of concepts, Theories, Processes and applications |
|---|---|
| **Information Systems management processes** | • Strategic planning for infrastructure and applications<br>• Evaluation of IS in the organization<br>• Management of IS personnel<br>• Management of IS function and operations |
| **Information Systems development processes** | • IS project management<br>• IS project risk management<br>• Project organization and participation<br>• Technical and social requirements<br>• Application acquisition<br>• System implementation<br>• Training, acceptance and use |

| Bodies of knowledge unique or somewhat unique to Information Systems | Examples of concepts, Theories, Processes and applications |
|---|---|
| **Information Systems development concepts** | • Method concepts<br>• Socio-technical concepts<br>• Speech act theory for collaborative development<br>• Rational decomposition concepts for requirements<br>• Social construction for requirements<br>• Error and error detection concepts<br>• Testing concepts for complex socio-technical systems<br>• Quality concepts for IS |
| **Representations in information systems** | • Database, knowledge and concepts<br>• Representations of the "real world."<br>• Coding<br>• Storage, retrieval and transmission<br>• Tracking events<br>• Representing events changes<br>• Representing system structure |
| **Application systems** | • Knowledge management<br>• Expert systems<br>• Decision support systems (DSS) and group DSS<br>• Collaborative work and virtual team systems<br>• Telecommuting and distributed work systems<br>• Training systems<br>• Electronic commerce systems<br>• Customer support systems |

Information Systems can be conceptualized in terms of three types of systems: Transactional Processing Systems (TPS), Management Information Systems (MIS), and Expert Systems. MIS has several subsets, such as Decision Support Systems and Executive Information Systems. Management Information Systems refers to a system that uses information in order to ensure apt management of businesses. Fundamentally, all the facets of MIS run concomitantly in order to ensure the overall efficiency of the whole system. The role of MIS in decision support is best discussed in the context of the subset referred to as Decision Support System (DSS). A DSS is a computer-based system (an application program) capable of analysing organizational (or business) data and then presenting it in a way that helps the user to make business decisions more efficiently and effectively. It is basically an informational application which depends on the information already input while answering a given query. For example, a decision support system could provide:1- Comparative sales figures for one week/month 2-Projected revenue figures based on new product sales assumptions 3- Consequences of different decision alternatives, given past experience. Usually, the DSS is used by all levels of people within a business organization. Top-level management uses DSS for strategic decisions, middle management uses it for tactical decisions, while first-line supervisors use it to deploy it for day-to-day operational decisions (Nowduri, 2011).

The Workflow of the Management Information System has clearly defined the communication process and level of information transmission and data processing throughout the organization. Below is a management information system that briefly explains the performance of the strategy to use for data processing into information transformation. Figure 4.1 clearly explains the processing need of data into information MIS process has a different

collection of data; sorting and dissemination of data and information for further processing on it all intelligence use their skill to analyse and evaluate the final decision (Taru Rupali Dilip, 2017).

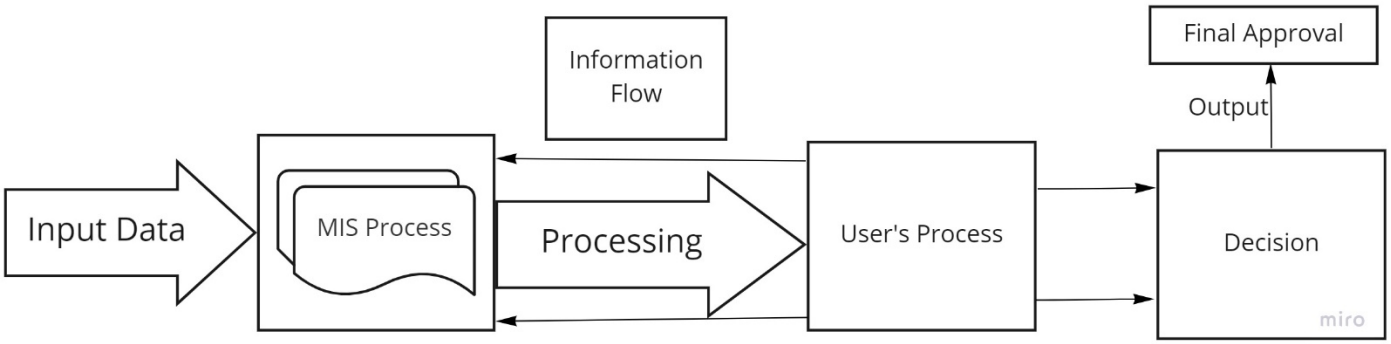


**Figure 4.1 Work-Flow of MIS**(Taru Rupali Dilip, 2017)

Asemi et al., 2011 found that MIS is best suited to identify problems and help management to understand them to make suitable decisions. At the same time, MIS is not aimed at helping particular and specific needs of the individual and group decision-making. On the other hand, DSS is tailored to the specific need of individual and group managers. Therefore, it could be concluded that DSS can extend its support to the same steps of the decision-making process and has more roles in decision-making and problem solving than MIS. Due to some practical limitations, maybe some of the steps of the decision-making process to be chosen and others be removed. It is important to consider which ones are preferred to the other ones. Consequently, IS concepts(MIS and especially DSS) have advantages in effective decision-making and improve management of the organization.

## 4.2 Decision-Making Within Facility Management

Nowadays, utilities such as bridges, highways, and filling stations, as well as buildings like hospitals, shopping malls, and residences, have encircled people's lives(Xu et al., 2019). A facility is a physical item that is created, installed, or erected for the purpose of facilitating social and economic activity (Kaplan & Norton, 2004). ISO 41011 defines facility management (FM) as "an organizational function that combines people, place, and process within the built environment with the goal of increasing people's quality of life and business efficiency" (Casini, 2022).

FM is a subset of management that focuses on the maintenance, development, and improvement of physical assets required to increase and progress the value of the business, as well as the creation and maintenance of a suitable physical workspace that provides optimal support for the organization's people and work (Drion et al., 2012).

FM may impact operational expenses, fuel consumption, interior comfort, and pollutants, all of which contribute to an environment's (organization's) efficiency. The estimated cost of insufficient interoperability in the capital facilities business in the United States is $15.8 billion per year, with about 57.8 per cent of the cost paid by owners and operators during facility operation and maintenance (O&M) (Gallaher et al., 2004).

Additionally, there is a widespread misconception concerning FM. The majority of people believe that FM is synonymous with outsourcing. However, it is the function of FM that fosters an environment conducive to outsourcing non-core business activities (Potkány, 2015). To be more precise, there are several fundamental operations that the major corporation does. Occasionally, they are well-known fundamental activities. On the other hand, there are supporting operations that are outsourced by the parent business; these are referred to as non-core activities (Somorová, 2007).

FM is defined by the interactions between three domains: people resources (human capital), work activities (achievement and funding), and work environment (architecture and engineering). It is understandable that the primary purpose of FM is to support the many components (requirements of employees and customers) of a business, facility, or infrastructure while keeping expenses as low as feasible (Potkány, 2015).

Clearly, FM may contribute to cost optimization in complex physical environments with a diverse range of assets, personnel, and also customers and users. Hospitals and hotels are examples of enterprises that require FM to improve their asset and facility management. FM as a phrase, practice, and study has been more prominent in situations where built facilities are a component of the organization's non-core operations.

Mari and Poggesi (2014) reviewed papers systematically on FM that has been published since 2006 in order to know the progression of research on this topic. Another purpose of this review is to understand the awareness of scientists about the role of a strategic approach towards FM could give to the overall success of an organisation and, if so, how they have a suggestion for implementation of this approach within the management of the firm. This review concluded this stream of research is still in the primary stage a has a slight shift toward a more strategic perspective of analysis. Some findings from the papers are shown below:

According to the approach towards FM, companies tend to contracting-out of non-core activities such as outsourcing over the last decade. Many activities such as building support services are outsourced in order to have a better concentration on their core activities. Cost reduction, organisational efficiency or souring value creation are some results of outsourcing in the analysed papers.

There are some drawbacks in analysed papers about FM. Almost all studies investigated only a single case study. Hence, it cannot help considerably to consequence generally. Moreover, descriptive approaches have been used in all of the papers, especially technical ones for analysing. In addition, investigations have shown that there is a loss between FM practice and consolidated management theories. These observations could be concluded that FM subject is more popular in practical studies than in academic scope. The value and necessity of managing facilities are revealed

when we know that costs of operating facilities are the largest portion of expenditures of companies after salary and wage.

Figure 4.2 (Potkány, 2015) depicts the scopes of the business area of FM services. As it is shown managing facilities has an important role in a company.

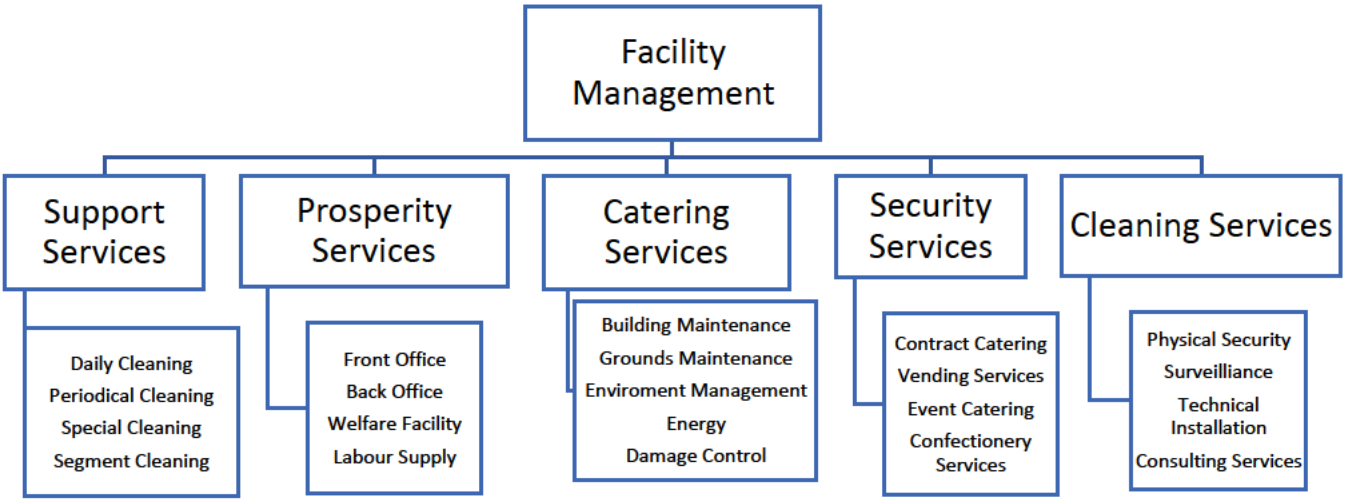


**Figure 4.2 business area of FM services**

Current FM decision-making is primarily reliant on manual input, setup, and operation, which can be unreliable because of human beings' limited computational capability and finite reasoning.

FM requires vast data, especially in complex built with some branches such as filling stations because of having a lot of assets, employers and so on. Hence, facility managers should decide on many subjects that it is pointed out previously (in Figure 4.2 business area of FM services). One of the essential proceedings for firms is illustrative, logical and precise decision-making. Decision-makers require a large amount of complicated organized information and also analysed with suitable methods. Nowadays, most companies should obtain, manage and analyse large-scale data. The value is produced through different sources, which allows a better understanding of the behaviour, needs, and abilities of the relevant actors (Yalcin et al., 2022). Decision-making involved in current FM relies heavily on manual input, setting and operation, which can be fallible due to the limited computation capacity and bounded rationality of human beings (Niu et al., 2016). So it is important to choose a method that data should be organized in a way that becomes applicant and effectively. An effective way for data arrangement is explained in the next parts.

Decision-making has widely been acknowledged due to achieved competitive advantages emerging from unstable environmental settings, As the decision-making approach helps organizations to identify the decision problems, environment, and effects on business growing performance (Chai et al., 2013). The decision-making also guides organizations to take diverse opportunities and encounter threats emerging from diverse environmental changes(Ali & Miah, 2018). Executives and managers spend a large amount of time scanning for information and making decisions(Vedder et al., 1999).

## 4.3 Business Intelligence And Dashboards

The organization's source of power has changed away from land, wealth, and material capital and toward intangible resources (Herschel & Jones, 2005; Negash & Gray, 2008; Wickramasinghe & von Lubitz, 2007). Information, knowledge, intelligence, intellectual capital, and wisdom increasingly rule enterprises (B. Wixom & Watson, 2010). Besides, the approach to corporate management has shifted dramatically during the previous decade. Firms have recognized the critical nature of enforcing the fulfilment of their strategy's objectives through metrics-driven management. Firms are reshaping themselves into new forms based on knowledge and networks in response to an environment marked by blurred organizational boundaries and rapid change. Enterprises are continuously attempting to outperform the competition while still maintaining compliance with shifting business cycles, security, globalization, and regulatory requirements. As businesses strive to adapt more quickly and effectively to business change, they are obliged to review the underlying architecture that underpins their operations in order to assess their future scalability. Understanding data and translating, moulding, and transforming it into networked markets is critical for any firm seeking a competitive edge. The key to every enterprise's success is figuring out how to integrate the massive amounts of data moving within and across business processes together and make sense of them(Ranjan, 2008).

As previously mentioned, a decision-making process consists of making judgments regarding several investments and resources based on quantitative and qualitative data. There are several different systems, such as data warehouse, Enterprise Resource Planning (ERP), etc., currently used by organizations for decision-making processes. These systems have progressed tremendously in the last few years by making large amounts of information accessible using(B. H. Wixom & Watson, 2001). These systems allow managers to analyse data depending on the business requirements. In this part, a DSS which is powerful is introduced. Then applications for this tool are explained.

### Definition Of Business Intelligence And Dashboard

Business intelligence is both a process and a product." The process is made up of techniques that businesses employ to generate meaningful information or intelligence that can assist them in surviving and prospering in the global economy. The product is information that enables firms to forecast with a high degree of accuracy the behaviour of their "competitors, suppliers, customers, technologies, acquisitions, markets, goods and services, and the overall business environment" (Jourdan et al., 2008). In other words, Business intelligence (BI) is a data-driven decision support system (DSS) that integrates data collection, storage, and administration with analysis to offer input to the decision-making process. The phrase arose in 1989; several of its properties were previously included in executive information systems. Business intelligence focuses on the analysis of vast amounts of data about a business and its activities. In computer-based systems, business intelligence makes use of a big database, generally housed in a data warehouse or data mart, as the source of data and the basis for advanced analysis. Recent innovations in business intelligence (BI) include business performance measurement (BPM), business activity monitoring (BAM), and the evolution of BI from a staff tool to one that is utilized by everyone in the company. In the long run, business intelligence methodologies and insights will be ingrained in corporate operations (Negash & Gray, 2008). Olszak (2016) collected several types of BI definitions that are illustrated in Table 5.

Table 5 The overview of BI definitions, Olszak, 2016

| Study | Definition |
|---|---|
| **Adelman and Moss (2000)** | An umbrella term to describe the set of software products for collecting, aggregating, analysing, and accessing information to help the organization make more effective decisions |
| **Alter (2004)** | An umbrella term for decision support |
| **Azvine, Cui, and Nauck (2005)** | BI is all about capturing, accessing, understanding, analysing, and converting one of the fundamental and most precious assets of the company, represented by the raw data, into actionable information in order to improve business |
| **Business Objects (2007)** | A system that provides different information and analysis for employers, customers, and suppliers to make more effective decisions |
| **Chung et al. (2005)** | Results obtained from collecting, analysing, evaluating, and utilizing information in the business domain |
| **Power (2007)** | An umbrella term to describe the set of concepts and methods used to improve business decision-making by using fact-based support systems |
| **Eckerson (2005)** | A system that takes data and transforms it into various information products |
| **Glancy and Yadav (2011)** | BI focuses on supporting a variety of business functions, using the process approach, and advanced analytical techniques |
| **Hannula and Pirttimaki (2003)** | Organized and systematic processes that are used to acquire, analyse, and disseminate information to support the operative and strategic decision-making |
| **Jordan and Ellen (2009)** | BI is seen as a critical solution that will help organizations leverage information to make informed, intelligent business decisions to survive in the business world |
| **Jourdan et al. (2007)** | BI is both a process and a product that is used to develop useful information to help organizations survive in the global economy and predict the behaviour of the general business environment |
| **Lonnqvist and Pirttimaki (2006)** | A managerial philosophy and tool that helps organizations manage and refine information with the objective of making more effective decisions |
| **Moss and Atre (2003)** | An architecture and a collection of integrated operational, as well as decision support applications and databases that provide the business community easy access to business data |
| **Negash (2004)** | A system that combines data collection, data storage, and knowledge management with analytical tools so that decisions makers can convert complex information into a competitive advantage |
| **Olszak and Ziemba (2003)** | A set of concepts, methods, and processes that aim at not only improving business decisions but also supporting the realization of an enterprise strategy |

| | |
|---|---|
| **Reinschmidt and Francoise (2000)** | BI is an integrated set of tools, technologies, and programmed products that are used to collect, integrate, analyse, and make data available |
| **Watson and Wixom (2007)** | BI describes the concepts and methods used to improve decision-making using fact-based systems |
| **Watson and Wixom (2010)** | BI is a broad category of technologies, applications, and processes for gathering, storing, accessing, and analysing data to help its users make better decisions |
| **White (2004)** | An umbrella term that encompasses data warehousing, reporting, analytical processing, performance management, and predictive analytics |
| **Williams and Williams (2007)** | A combination of products, technology, and methods to organize key information that management needs to improve profit and performance |

Not to mention opinions differ on how to classify BI systems under the category of information systems; some writers define BI systems as data-driven decision support systems. At the same time, some writers believe that business intelligence systems will eventually supplant executive information systems(Power, 2002).

A dashboard is a single-screen user interface that consists of a static structure which makes information available at the right time using indicators. A dashboard provides an interface that aids managers and executives in getting data immediately from various departments in a similar format and makes it more accessible. Dashboard design also plays an important role in the decision-making process. It should be easy to use and should consist of all the capabilities such as customization, audience targeting, colour display, etc., to facilitate the decision-making process. Depending on the specific business application where a dashboard is used, the design and functionalities may vary (Golfarelli, Rizzi, Formula, et al., 2004).

A dashboard management system should focus on interface design, accessibility and security. Dashboards should be easy to use, web-accessible and business-driven. For an organization, cost also plays an important part, so dashboards should be affordable and easy to deploy as well (Njuguna, 2011).

Figure 4.3 illustrates the basic structure of how the Dashboard fits into the decision-making process. The Dashboard integrates the data warehouses and analytical models directly into the decision-making process. This is a continuous process based on ongoing environmental scanning and feedback from current performance metrics, e.g., inventory turns. Behind the graphical interface lie the supportive analytical systems such as statistical analysis for data validation, combined forecasting algorithms, and expert systems for decision options analysis and recommendations(Hall, 2003).

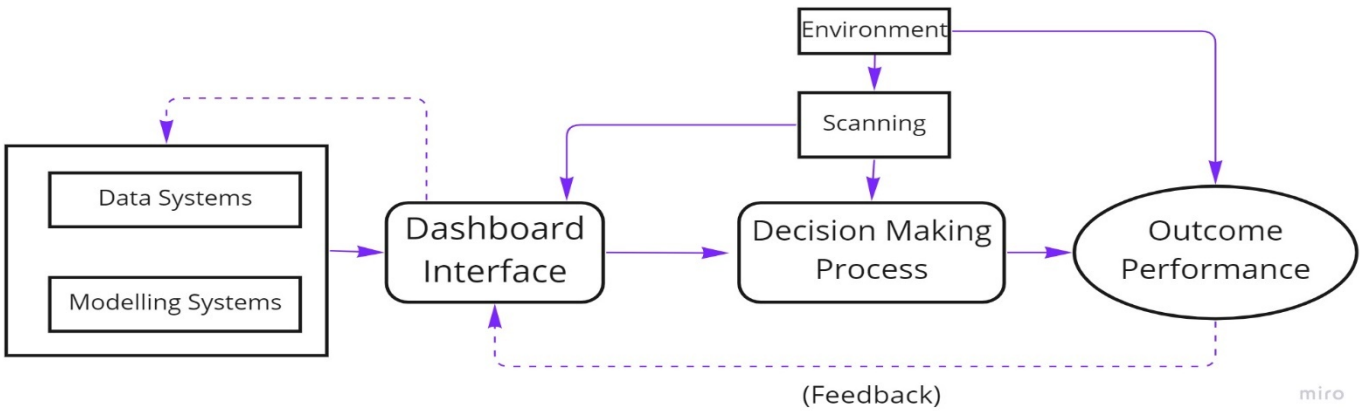


**Figure 4.3 The Dashboard Interface Structure (Hall, 2003)**

## History of BI and Dashboard

In the mid-1990s, the BI system was widely accepted as the data warehouse. A data warehouse is a subject-oriented, integrated, time-varying, non-volatile collection of data that is used primarily in organizational decision-making. Though a data warehouse was commonly used, it was only beneficial to people who were highly computer literate. The main problem faced by business users while making decisions is navigating through huge data marts or data warehouses and correlating the information. In order to access the data, business users have to be dependent on the IT department (Hansoti, 2006). BI dashboards help in solving this problem by consolidating and making information available on a single screen. A BI dashboard allows business users to have complete control over how they manage the data, while IT can be more involved with technology integration, maintenance and support. Severing this interdependent relationship results in faster and better decisions (Hansoti, 2006). The quality of decisions depends highly on data quality. Availability of data is also considered a data quality issue. As compared to a data warehouse, the data in a dashboard comes from multiple sources, including data warehouses, spreadsheets, internal applications, external services and standalone applications. In a survey carried out by Hurwitz and Associates, it was found that the companies relying on data warehouses and stand-alone databases meet less than 50 per cent of their business requirements. According to the survey, most companies incorporate their data warehouse and external applications into the dashboard to achieve better performance. Nearly 95 per cent of the IT executives surveyed recommended a dashboard as a tool to offer consistency, reliability and accuracy necessary for better decision-making capabilities (Hansoti, 2005).

Three ages are distinguished, named BI 1.0, BI 2.0 and BI 3.0. The first age of BI falls in the 1970s and 1980s of the 20th century. The second age is associated with the further development of advanced data warehouses, OLAP techniques, data mining, and, first of all, with internet and web technology (Web search engines, such as Google and Yahoo). There is a growing acceptance of the idea that analysis is a collaborative (not only singular) and social effort. BI 3.0 should go beyond reliance on structured data available in internal sources but should also use external, mostly unstructured, data from various (Olszak & Ziemba, 2006).

## Components of business intelligence

BI tools are widely acknowledged as a new middleware layer between transactional and decision support applications, divorcing systems optimized for efficient transaction processing from systems optimized for efficient decision support. Decision support, OLAP, statistical analysis, forecasting, and data mining are all capabilities of business intelligence. The following are the primary components of business intelligence(Ranjan, 2008):

**Warehouse of data:** The data warehouse is a critical component of business intelligence. It is subject-oriented and comprehensive. By managing the multiple corporate records for integration, cleaning, aggregation, and query operations, the data warehouse enables the physical propagation of data. Additionally, it may contain operational data, which is described as an updatable collection of integrated data utilized for enterprise-wide tactical decision-making in a certain subject area. It uses real-time data, not snapshots, and preserves just a limited amount of history (Ranjan, 2008).

**Data sources**: Data sources include operational databases, historical data, external data (from market research firms or the internet), and data warehouse information. Databases or other data structures supporting business applications can be used as data sources. They can also be on various platforms and contain organized (tables or spreadsheets) or unstructured (plaintext files, images, etc.) data(Ranjan, 2008).

**Data Mart** (Inmon & Productions, 1999) defines a data mart as a collection of topic areas structured for decision support depending on departmental needs. Finance has one; marketing has one; sales have one, etc. And the marketing data mart is unlike any other. Most crucially (Inmon & Productions, 1999), each department owns its own gear, software, data, and applications. Each department's data mart is unique and tailored to its own needs. Analysing historical trends and experiences helps business specialists strategize using data marts, like data warehouses. The main

distinction is that a data mart is built around a predetermined need for data aggregation and configuration. A business may have many data marts. A data mart can support a business function, process, or unit.

**Query and reporting (Q&R) tools**: OLAP provide multidimensional, summary representations of company data for reporting, analysis, modelling, and planning. Work with data warehouses or data marts for advanced corporate intelligence systems using OLAP techniques and technologies. These systems answer questions about trends and crucial aspects. Reporting software creates aggregated data views to keep management informed. Other BI technologies include data mining, data warehouses, decision support systems, forecasting, knowledge management, mapping, information visualization, dashboards, management information systems, geographic information systems, trend analysis, and Software as a Service (SaaS). (Ranjan, 2008)

Figure 4.4 depicts a typical BI environment. Multidimensional analysis (OLAP, for example), click-stream analysis, data mining, forecasting, business analysis, balanced scorecard preparation, visualization, querying, reporting, and charting (including just-in-time and agent-based alerts), knowledge management, enterprise portal implementation, mining for text, content, and voice are all possible with BI decision-support applications. An enterprise data warehouse (EDW) is a database that stores information about a company or organization.

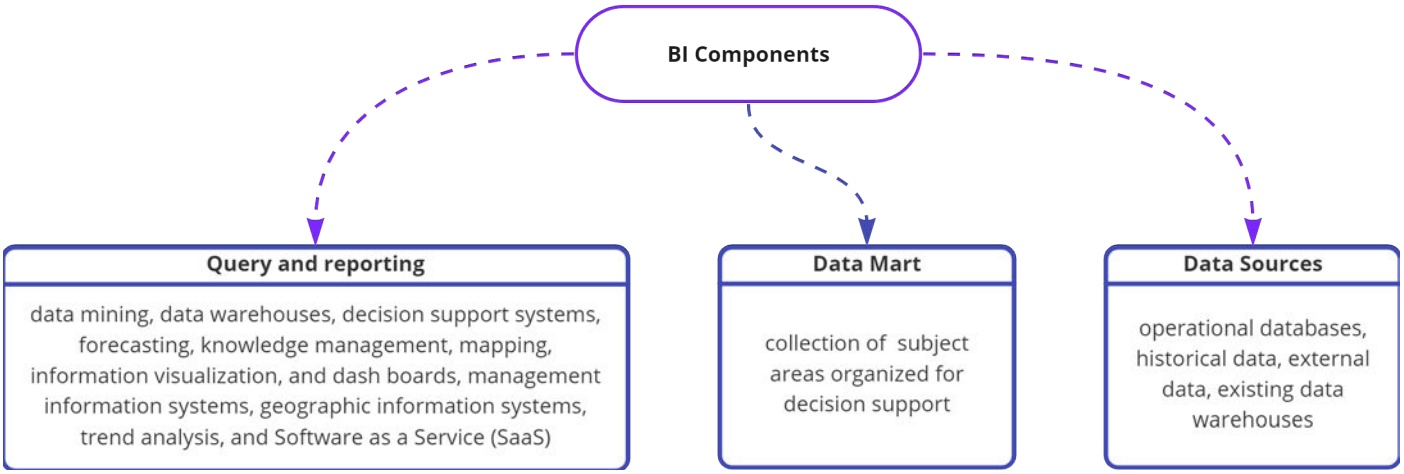


**Figure 4.4 Based on Ranjan J. (2008), Components of BI**

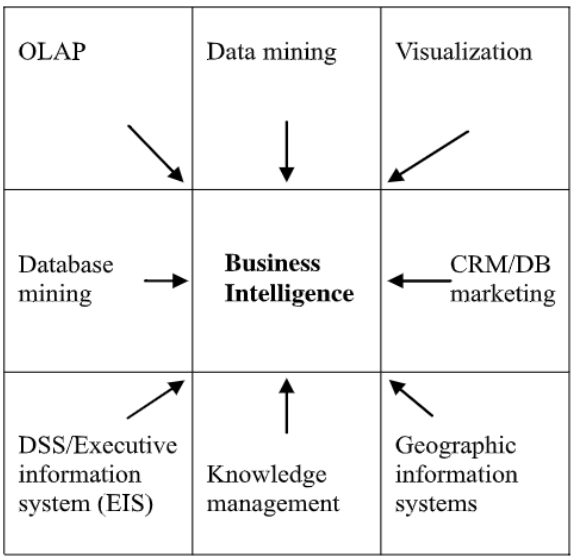


**Figure 4.5 obtained from Negash & Gray, 2008**

As it is shown in Figure 4.5, Business Intelligence integrates all of these components such as OLAP, data mining, visualization, database mining, DSS/Executive Information System (EIS), Knowledge management, and Geographic Information Systems (GIS) into a single (Negash & Gray, 2008).

## Role of Analytics

Analytics' purpose is to inform managerial choices and actions. Data alone is insufficient to accomplish this task. The data must be analysed in light of the firm's strategic and tactical objectives. Analytics serves as the foundation for both human and automated decision-making. Effective information management, often aided by a data warehouse, is critical. Analytic capability is contingent upon both human capital and organizational infrastructure. Professionals in business intelligence must be competent, computer literate, and hold advanced degrees in their respective professions (Negash & Gray, 2008).

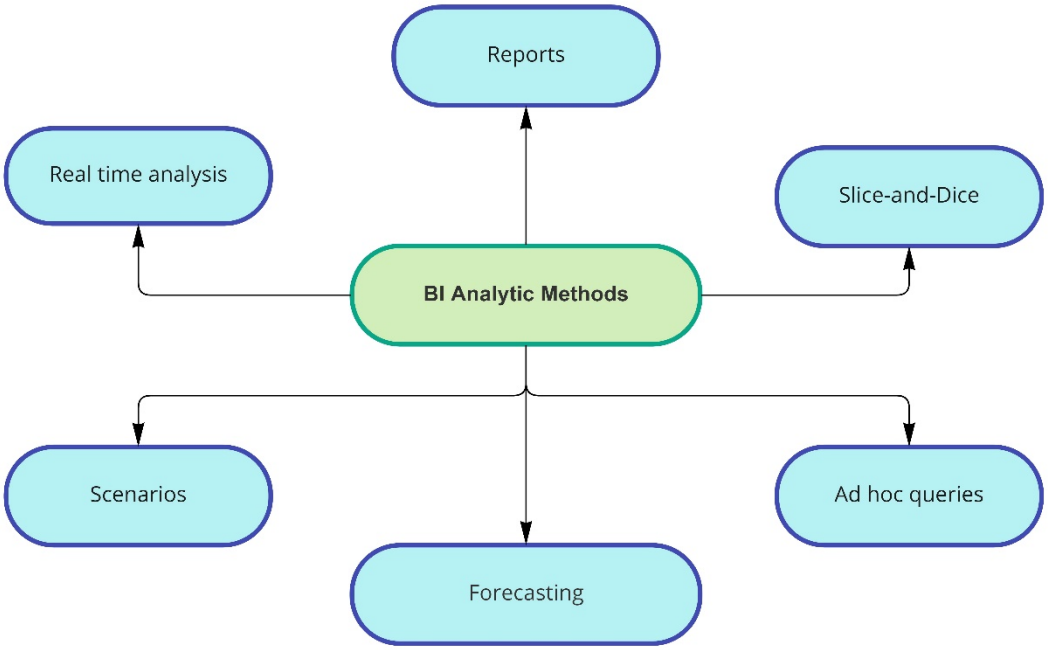


**Figure 4.6 BI Analytic Methods**

## Implementations of Software

Companies that provide business intelligence solutions fall into two categories: those that specialize in business intelligence, such as Information Builders, MicroStrategy, Panorama Software, QlikTech, and Actuate, and those with a much broader range of interests, such as Microsoft, Oracle, IBM, SAP, and SAS Institute. The business intelligence platforms may be general-purpose or vertical-specific. In the first category, the business must rely on a team of IT professionals to develop the business intelligence application according to its specifications. On the other hand, vertical business intelligence solutions are packaged specifically for a single industry or sector, such as banking, insurance, manufacturing, hospitality, education, or government. (Tutunea & Rus, 2012)

S&T Group provides business intelligence solutions in Russia. BI produced on industry-leading software platforms, such as Cognos, MicroStrategy, or SAP Wizrom, enables Business Intelligence Panorama Singular Logic Software – provides a business intelligence solution for business strategy. Advanced Software Solutions provides a business intelligence

solution. XPERT Business Analyzer was designed utilizing Microsoft's BI platform and ProClarity's analysis tools. (Tutunea & Rus, 2012)

The business intelligence solutions/products include modular functionality, which includes Dashboards, localization and business data visualization, what-if analysis, interactive reports and sharing. Dashboards Are readily customisable, enabling better and faster decision-making in real-time. Additionally, critical performance indicators, alert generators, and exception reports are included. Localization and display of business data in a geographical or geo-locational manner. What-if analysis enables business leaders to evaluate the possible impact of business actions in simulated phases prior to meeting reality. Interactive reports assist the ultimate beneficiary in transforming data into knowledge by enabling visualization and analysis via a variety of report kinds and visuals geared for decision assistance. Sharing and providing information to consumers in a way that is readable and understandable. (Tutunea & Rus, 2012)

## Monitoring Dashboards

As with dashboards on automobiles and aeroplanes, digital dashboards give information about a company's key performance metrics' present and historical status (KPI). A standard dashboard communicates business intelligence findings using simple visualizations (gauges, charts, and tables) via a web browser interface. Dashboards are interesting because they:

•Consolidate a variety of data into a single consolidated view on the screen

•Consolidate information into high-level summaries

•Use intuitive indications that are easily comprehensible.

For instance, red denotes a problem, yellow suggests possible trouble, and green shows that everything is going according to plan. They inform the user of what is occurring but not why. However, dashboards can have drill-down features that allow for the contextualization of current data. Because users' requirements vary, dashboards may be tailored to meet specific requirements(Negash & Gray, 2008).

Different departments in an organization use a dashboard differently to serve their unique needs. The way departments use a dashboard may make a difference between failure and success. Sales and Marketing generally use a dashboard to forecast sales and collect information on pipeline, unit orders, and prices (Malik, 2005). Supply Chain uses a dashboard to manage distribution, inventory, logistics, and monitor return rates (Malik, 2005). The IT department makes use of a dashboard for managing resources, scheduling, and calculating cost and time on any project.

## Guidelines For Implementing Bi (Checklist)

BI implementation is directly related to the array of activities such as data gathering and warehousing, historical data recording, analysing, synthesising, and transforming them into decision-support information(Singh & Singh, 2013). BI helps to process given information and create IT usability for making the decision using pertinent technology ((Singh & Singh, 2013). As BI plays a significant role of IS in understanding customer needs through processing and transmitting required information (Martinsons & Davison, 2007) and making the decision to satisfy the customer needs, BI became the best conductor of information management practices, in particular for decision support in businesses.

(Cates et al., 2005) provide steps for successful implementation of BI framework in organizations. Also, (Ranjan, 2008) provides here some guidelines that can be considered for BI implementation in an organization. There are four steps which step include some points that could be shown below:

## Requirements from firm perspective

- Corporate mission and vision statement
- Reasons for embracing a centralized, managed approach to BI
- Justification of BI acquisitions using application specific use, end-user surveys and request, IT decisions
- Tracking and measuring the BI efforts and BI support structure

## Details of users and corporate standards

- Details of a thorough end-user segmentation and evaluation methodology
- Details of a standard for BI tools: education and support
- Details of end user's requirements to the current tools
- Details of corporate infrastructure (user group, newsletter, etc.) for BI and their processes
- Documented and approved BI strategy for external and internal users
- Details of percentages in time and expense for BI activities

## Details of databases, tools and vendors

- Details of enterprise-wide database
- Database strategy and corporate strategy for BI for thin client access
- Analytics tools and their architecture requirements
- Details of BI database architectures, data warehouse, data marts, federated(multi-source) data access, OLAP, and others
- Details of BI database decisions based on technology, platform regardless of the vendor's solutions, BI-specific functionality, IT preferences and standards
- Details of vendors: vendor applications and packages
- Details of BI budget, including software costs, hardware upgrades, usertraining and education, outside consulting services
- Details of available BI tools and their impact on existing processes

## Others requirements

- Details of production libraries and production databases, the daily, weekly,and monthly extract/transform/load (ETL) processes on the job scheduler
- Details of regularly scheduled application report programs, scheduled meta data repository programs
- Concerns of operations staff towards quality assurance (QA) test results
- Details of security measures, user authentication services, database maintenance, backup and recovery procedure, and disaster recovery procedure
- Concerns of the business people receiving training

**Figure 4.7 Guideline for implementing BI** (Ranjan, 2008)

Jourdan et al., 2008 conducted research that gathered, synthesized and analysed 167 publications on a variety of business intelligence (BI)-related issues published between 1997 and 2006 in 10 important Information Systems (IS) journals. They discovered an overall increase in activity over a ten-year period and a preference for exploratory research approaches. In their study, they categorized the BI literature up until that time into four categories that can be seen in Table 6. They discovered five different groups when they evaluated the papers. The category of Artificial

Intelligence (AI) encompasses AI methods and applications. The AI area included applications for categorization, prediction, web mining, and machine learning. The Benefits category describes how firms have benefited financially from data warehousing, data mining, and/or enterprise-wide business intelligence solutions. The Decision category comprises articles on topics such as data modelling, decision-making, and decision modelling. The Implementation category encompasses all aspects of project management. In their study, they concluded that the area of added benefits of BI is not fully explored compared to other areas. One of the reasons for the scarcity of publications published in this field is possibly the difficulty of quantifying the advantages of enhanced decision-making ascribed to business intelligence systems.

**Table 6 Categorization of BI research topics until 2006** (Jourdan et al., 2008)

| Category | Topics | Number of Articles |
|---|---|---|
| **Artificial Intelligence** | Algorithms, Classification, Machine Learning, Prediction, Web Mining | 37 |
| **Benefits** | Data Mining, Enterprise-wide IS | 10 |
| **Decisions** | Data Modelling, Decision-making, Decision Modelling | 26 |
| **Implementation** | CRM, DM, DSS, DW, business, ERP, KMS, Project Management | 35 |
| **Strategies** | Collaboration, Competition, Customization, Integration, etc. | 59 |

Olszak (2016) analysed the literature and conducted surveys, and the result was that BI is a very complex issue that needs scientific discussion and investigation. BI may be a trigger for making more effective decisions, improving business processes and business performance, as well doing new business. BI requires permanent development and adaptation to new challenges and expectations of organizations. Factors that allow organizations to achieve business benefits with BI include management leadership and support, corporate culture, expressed by effective information resources management, clearly stated strategy and objectives, and use of appropriate BI technologies. Additionally, the important factors were clearly defined business processes, business performance measurement, an incentive system to encourage collecting and analysing information and knowledge sharing, appropriate resources (financial, intellectual), and training and education on BI and knowledge management. The study highlighted that the BI development, as well as its measurement and assessment, should be based on proven and scientific theories. Three theories were utilized to analyse Business Intelligence issues: the Resource-Based View (RBV), Maturity Models, and Critical Success Factors (CSF). CSF gives a sound basis for stating what criteria should be followed during the development of BI. Maturity Models provide the ways and guidelines to assess BI in organizations. RBV allows us to treat BI as an organization's capability that enables improving decision-making, firm performance, and adoption to a changeable environment. RBV and dynamic capabilities characterize BI as an IT-enabled, analytical tool for enhancing decision-making, company performance and adaptation to changing environments(Chae & Olson, 2013; Ortbach et al., 2012; B. Wixom et al., 2011). BI skills help firms to modify business models, investigate and adapt to new surroundings. These include: "analytically impaired", "localized analytics"," analytical aspiration", "analytical companies", and" analytical competitors". These steps show how organizations may establish sponsorship, culture, skills, data, and technology needed for analytical competitiveness(Olszak, 2016).

An organization's strategy determines the configuration of its resources and capabilities that are the basis for building key competencies. It is stated that resources should be VRIN: Valuable (enable an organization to implement a value-creating strategy), Rare (are in short supply), Inimitable (cannot be perfectly duplicated by rivals), and non-substitutable (can't be countered by a competitor with a substitute). The RBV conceptualizes organizational resources astatic, neglecting changes due to turbulent environments. A stable resource configuration cannot guarantee long-term competitive advantage(Olszak, 2016)

The practice demonstrates that the success of BI is still debatable. Numerous business intelligence solutions are implemented incorrectly. Organizations do not derive the desired benefits from their use of business intelligence (Isik

et al., 2011; B. Wixom & Watson, 2010). Around 60%–70% of business intelligence applications fail to owe to technical, organizational, cultural, and infrastructural difficulties(Clavier et al., 2012; Hannula & Pirttimaki, 2003). Many firms struggle to make business intelligence a useful tool for decision-making and competitive advantage creation.

Torres et al. (2018) address a gap in the scholarly literature by establishing a theoretical framework for the role of BI in achieving firm performance that is grounded in an established strategic management theory. They argue that BI represents sensing and seizing components of dynamic organizational capabilities. As such, BI&A acts as an enabler of organizational transformations and thus contributes to improved organizational outcomes. The development of BI sensing and seizing capabilities relies on well-established managerial processes and sophisticated technology infrastructure. The conceptualization of BI as an essential component of dynamic capabilities helps explicate how BI contributes to improved organizational outcomes answering the call for research on the organizational and strategic uses of BI and their impact on firm performance(Jourdan et al., 2008). Building on the (sense-seize-transform) SST view of dynamic capabilities(Teece, 2007), they demonstrate BI enables organizations to sense opportunities and threats and seize those occasions through improved decision-making. Further, this research links the use of BI to improved organizational outcomes through the transformation of business processes, consistent with the view that the value of IT is derived from its impact on the value-generating processes of the firm. Finally, they demonstrate the relevance of BI success factors in extant research to the development of superior BI&A sensing and seizing capabilities. They contribute to the existing research on BI&A, IS success and firm performance by empirically testing a model which integrates these theoretical perspectives(Torres et al., 2018).

Fink et al. (2017) result in the reasoning that operational and strategic BI capabilities should be considered separately and that organizations may become ambidextrous in their BI capabilities in the same way they can become ambidextrous in their approach to organizational learning. This study advances the perception that business value is generated from BI assets via two parallel mechanisms, operational and strategic, based on two orthogonal sets of respective capabilities. This dual approach to BI value creation represents the next step in the evolution of BI business value models. They showed that organizational resources, in particular the degree to which the organization has an exploratory orientation, have an effect on the transformation of BI assets into strategic BI capabilities. This line of inquiry, which draws on knowledge established in other areas of information systems research and organizational theory, has the potential to significantly advance our understanding of the organizational contribution of BI.

## Advantages of BI and dashboards

When considering the benefits of BI solutions for decision support, must consider the following the quality of business information provided, powerful tools for data analysis and visualization, lower cost of decision-making, web-based accessibility, and increased efficiency and effectiveness of decisions. In a competitive environment, making the correct choice at the right time and using an effective business intelligence solution may become a persistent competitive edge for any small-to-medium enterprise (SME). According to (Tutunea & Rus, 2012), SMEs may pick from a variety of business intelligence software solutions, beginning with open-source options and progressing to very feasible alternatives such as SaaS solutions and Cloud BI.

The objective of investing in business intelligence is to shift from a reactive to a proactive approach to data. A primary objective of business intelligence is to automate and integrate as many processes and services as feasible. Another objective is to give analytics data that is as tool-independent as feasible. We are entering an era in which bundled business intelligence solutions are required. One of the driving forces behind these initiatives is the requirement for senior management to get advanced analytics and assessments(Ranjan, 2008).

To make the type of real-time judgments necessary in today's businesses, business users must be able to swiftly filter through a growing amount of knowledge and information while maintaining high operational efficiency. A few years ago, consumers were accustomed to lengthy wait times for their requests to be completed. Today, they demand the capacity to create their own dashboards, manage embedded analytics, and generate their own reports using a standard web interface; all of this is possible with the correct business intelligence tools integrated into a complete framework(Ranjan, 2008).

Often, even the most advanced firms lack clearly accessible and well-articulated strategic business goals statements. This is accomplished only by making an exhaustive analysis of the organization's annual report, public remarks, press coverage, syndicated articles, and internal memoranda for pertinent material. The process of business justification is iterative. As tough as it may be to defend the business case, it is important to remember that company managers are aware of the buzz surrounding business intelligence and would like to capitalize on any competitive edge they can obtain. Reiterating the benefits can help solidify the business case and ensure that everyone feels comfortable sponsoring BI efforts(Ranjan, 2008).

## 4.4 Applications of business intelligence in facility management

In previous parts, the FM definition and the importance of Decision-making (DM) in FM were explained. Moreover, the role of DSS in decision-making was another subject that was mentioned. Also, BI was introduced as a DSS. It should be said that dashboards are useful BI tools that have a significant role in DM. In this part, some applications of BI in FM are described and eventually research gap is discovered.

FM industry, to date, seems to undervalue the necessity of taking advantage of the benefits that data orientation provides. For instance, (Nardelli & Rajala, 2018)) discusses the evolution of BMs within FM, focusing on BMI – yet their research stresses the aspect of inter-organizational collaboration across different phases of the innovation process, leaving data itself aside. A report for the Royal Institution of Chartered Surveyors clearly indicates the need for gathering, processing and taking advantage of knowledge within the FM industry. That being said, both monetization of data-based products and fitting such products into FM Business Models (BMs) are neglected by the report(Ware et al., 2017). Similarly, a report jointly branded by the International Facility Management Association and the Royal Institution of Chartered Surveyors (Ware et al., 2017) says a lot about adapting BMs to take advantage of new technologies but provides neither real-life examples of such changes nor guidelines for introducing them.

The BMs used to date in numerous industries, including FM(Nardelli & Rajala, 2018), feature technological components or abstract constructs that potentially bring together systems and applications of both transactional and analytical nature. However, the fact that in the era of Big Data and BI, data is the fuel supplying organizational knowledge and wisdom necessary for agile business operations seems to be neglected. Then, although reports from international organizations confirm that FM BMs shall evolve toward data management, it is challenging to identify best practices or real-life applications of reference models that may constitute the basis for tailor-fitting.

According to (Lönnqvist & Pirttimäki, 2006), BI Benefits for companies include reduced cost, increased revenue, enhanced business performance and better decision-making. However, many companies struggle to manage their BI solution because it is complex and requires ongoing management(Davenport, 2012).

Building upon concepts derived from the Digital Infrastructure Theory, which focuses on the continuous interplay between people and technology (Wanda & Stian, 2015), found that while the Norwegian industry still has a traditional, complex BI architecture, it is scalable in the sense that they can add or remove elements, or even scrap the whole BI solution. The companies demonstrate innovation and adoption through their use of dashboards and real-time data.

Barycki (2020) analysed the implementation of BI technologies for water connection asset management. Compared to distribution pipes, this type of asset is distinguished by its huge volume, technical variability, and absolute number of breaks. This mix of circumstances, together with a large number of data, makes it difficult to maintain a constant oversight and transparent translation of performance data into strategic goals and explicit service level agreements. The case of Evides prompted a study strategy that evaluates the implementation of a custom-built decision support system for the process of providing recommendations in asset management of water connections. The results show that the produced application improves the accessibility and connectedness of corporate performance data, contributes to increased transparency in goal formulation, and enables data-driven suggestion-making for asset management of water connections for the case study company. Accessing and pre-processing performance and technical data, as well as combining larger datasets into their analysis, are the areas where BI tools have shown to be the most beneficial for asset managers. It was demonstrated that the developed BI tool encourages engagement with data in user-defined ways, as opposed to the database-architecture-centred method where raw data must be integrated each time.

Another example of using the BI is in CAT Telecom Public Company Limited. It is a state enterprise under the Ministry of Information Technology and Communications in Thailand. It provides different types of telecommunication services such as the Internet, data communications, international dialling, electronic business, IT security, and CDMA cell phones. One of its important missions is to expand the network and increase the potential of telecommunication services for better quality and efficiency to cover all areas nationwide. At present, the number of Internet users is

rising, and it is widely accepted that the Internet has been involved in many areas of human life. Better quality of services is required to serve the users' expectations and needs. For these reasons, the organization has to develop its services to meet higher standards and customer satisfaction as much as possible. (Tanphet & Wanchai, 2018) BI technology was applied to analyse the data of the Maintenance Department of CAT Telecom Public Company Limited for the past four years during 2013-2016, including 131,456 records. The cause and time of the difficulty of equipment were defined using data mining and association rules. The result shows that applying BI technology in the organization could help the organization to prepare the plan of equipment maintenance and repair in advance to save time and reduce handling costs more effectively.

Yet, with the many millions of dollars of investment in ERP-style systems, ENGINEERING ASSET MANAGEMENT ORGANISATIONS(EAMOs) have been storing vast volumes of transactional data, leading to increased difficulties in analysing, summarizing and extracting reliable information. Consequently, in order to solve these problems, EAMO executives sought to leverage decades-long investments in information systems and data maintenance to improve business decision-making. Many progressive EAMOs have turned to implementing BI systems to better manage assets, and this has included transmission and distribution facilities, machines and pieces of equipment, supplier and customer relations, and personnel(Yeoh et al., 2006).

Wieder & Ossimitz (2015)presented novel insights into the direct and indirect effects of BI on the quality of managerial decision-making. The results of Partial Least Square (PLS) and mediation analysis indicate that BI management quality has direct and/or indirect positive effects on data quality, information quality, and the scope of BI solutions. Implications for practice include the fact that proper management of BI is crucial for data and/or information quality, the spread of BI, and, ultimately, the benefits of BI. In addition, managing data to ensure correctness, consistency, completeness, transparency, and thus trust in data is an important prerequisite for achieving high levels of information quality, but to excel in the latter, the right tools are required to easily access only relevant and up-to-date information.

One of the biggest challenges institutions face with managing sustainability is the collection, integration and reporting of sustainability information. Scholtz et al. (2018) indicated that the usability of the BI tool was positively rated and that the framework can assist in overcoming the constraints that (Higher education institutions) HEIs face in effectively managing sustainability information. Moreover, Pina, 2011 highlighted the key role that BI tools play in effectively managing sustainability information in HEIs. The successful implementation of BI tools can ensure that management benefits from improved access to accurate and up-to-date information when desired. These tools can provide strategic management and other stakeholders with a complete view of the organisation, thus providing benefits such as the ability to enable faster, more accurate and more reliable decisions (Scholtz et al., 2018).

# 5 Interview Setup

As mentioned in the methods section, this study will rely primarily on interviews to acquire data. Interviews may be a viable method in a case study setting since the primary source of data in that setting is people, and the notion of decision-making is a human-related subject. Additionally, given the paucity of research in the domain of facility management of filling stations and data-driven decision-making within it, the interviews can provide an excellent opportunity for exploratory research. As a result, the interview approach used was semi-structured.

Semi-structured interviews were used as the major way of eliciting information on AECOM's present practises, decision-making, and business goals regarding FMC. Structured interviews were selected owing to their superior control over the interview's themes and format (Kajornboon, 2005). However, following a precise guideline, as structured interviews demand, may preclude digging for pertinent information that is not disclosed (Ibid.).

It is expected that information will occasionally be provided implicitly during interviews, necessitating some degree of behavioural flexibility in order to extract it. Unstructured interviews (a.k.a. narrative interviews) were deemed unsuitable for this research's goal since coding and interpreting the data would be challenging if the questions were not the same for all participants (Stuckey, 2013). Semi-structured interviews, on the other hand, provide for a predefined question list with the option of probing for the interviewee's ideas and opinions (Kajornboon, 2005). This is significant because certain components of the decision-making framework may not yet exist formally at the case study firm. A semi-structured interview, on the other hand, enables the best follow-up on individual decision-makers.

## 5.1 Quality Control Methods

Data validation is not particularly prevalent in qualitative research, as it is more closely tied to quantitative research methodologies. Additionally, the purpose of this study is to ensure the research's quality. The most often mentioned set of qualitative research quality standards is the one created by Guba, Lincoln, and colleagues (Guba, 1981; Lincoln, 1995; Lincoln & Guba, 1985; Lincoln et al., 2011). They promote five critical ideas for evaluating the quality of qualitative research: credibility, transferability, dependability, confirmability, and authenticity (Table 7). These facets of quality will be assessed later on based on the definitions provided to control the quality.

Table 7 Treharne G., Riggs D. (2015), Concepts for defining and investigating quality in qualitative research

| Concept | Definition and approaches to Investigation |
|---|---|
| **Credibility** | Do the participants or members of the community under investigation believe the findings accurately reflect their experiences? Prolonged involvement with participants, negative (divergent) case analysis and triangulation are all activities that increase the likelihood that research will provide credible findings (of sources and researchers). Credibility can be investigated by member checking and peer debriefing with other researchers. |
| **Transferability** | Are the findings generalizable to other situations? By providing a detailed account of participants' replies (as well as the researcher's interpretations), transferability may be evaluated more easily. Naturalistic generalization happens when the findings corroborate the researcher's experiences and hence appear transferrable to the reader. |
| **Dependability** | Would comparable findings be obtained if another researcher conducted the investigation as well? Triangulation can be used to examine reliability across researchers. Additionally, auditing can be performed to enable another researcher to follow the audit trail created by the original researcher. |
| **Confirmability** | Are the findings the result of the participants' replies rather than the researcher's 'biases, objectives, interests, or viewpoints? Auditing can be used to determine the veracity of conclusions. |

| | |
|---|---|
| | A more open description of the findings (with signposted reflexivity) facilitates the evaluation of confirmability. |
| **Authenticity** | Is the study representative of a diverse variety of opposing opinions on the subject? Do the discoveries have the potential to be transformative? Is there widespread agreement that the findings are 'valuable and [have] meaning? Member checking can be used to ascertain the apparent legitimacy of participants or other members of the community in question, referred to as 'end users in certain cases. These individuals may include practitioners who may alter their practices in light of the findings. |

## 5.2 Interviewees

Based o the literature review conducted, BI adoption within firms' decision-making can be divided into two categories: Strategic decision-making at the top management level and operational decision-making. The aim of this study is the former type. Thus, the interviewee's target group consists mostly of people responsible for decision-making. The candidate identification was made by investigating the company's organization chart (Figure 5.1) and using the personal familiarity with the case study environment acquired during a one-year work experience. Also, initial explorative interviews were also used to identify the candidates. Participants will be chosen from inside the organization based on their proximity to the subject. Thisrequiresa separation between FMC maintenance and CM/ AI. Interviews with members of the organization's management team will give insight into important but broader global corporate goals, such as asset and maintenance strategy.

As seen in Figure 2.1 contractual relations, The FMC breaks down into Maintenance and CM/AI programs. These two programs are directed by the maintenance operation manager and Interview participant. It can be concluded that the mentioned people are key in decision-making with AECOM FMC and thus were included in the pool of interviewees. The project controller and the FMC finance lead were also interviewed because of the dominance in the finance section, as the investment decision was expected to be an important role player in the decision-making. Moreover, The IT lead from the Data team was selected due to the importance of data in this study, and finally, Interview participant was interviewed because of his affinity with data-driven decisions made within AECOM. This makes the total number of interviewees seven individuals.

## 5.3 Interview Format

To ascertain the intended usage and compare it to the system's acceptability and actual use, the concerned stakeholders will be questioned twice. One interview will be performed before the deployment of the BI Dashboard, and a second one will be conducted after system use. This corresponds to the period allotted for the case study. All interviews will be conducted by the Author. Each interview will have a format that will be followed as much as possible during the interview to give it a semi-structured layout. The interviews shall be as comparable as feasible to facilitate comparisons. In all interviews, the same framework is used. The beginning starts by discussing the background of the research and what the interviewee may expect from this interview. The interviews themselves are then separated into two categories, each with its own introductory question. These categories are deliberately distinct from the propositions since the intention is to mix questions and topics that are meaningful and rational to the interviewee rather than those that are connected to this research. Following the interviewee's initial response, it will be determined whether leftover questions are pertinent. These lingering questions may be important if the respondent did not include them in their responses earlier or if they did not adequately support their response. By employing this method, it is possible to distinguish between what the interviewer considers to be most significant. Everything the interviewees give without more advice or questions is seen as more significant and relevant than the facts taken from them through subsequent questioning. Figure 10 depicts a visual representation of the interview framework; the whole interview structure is included in Appendix A.

Each interview will last approximately 30 minutes and will be conducted via Microsoft Teams Meeting. This saves both the interviewee and the interviewer travel time and also includes built-in capabilities such as quicker recording and transcribing of the interview. All files will be saved on the AECOM cloud storage, with the Authors account granted private access.

Throughout the interviews, notes will be taken for the purpose of creating summaries. These summaries will be shared with interviewees for approval in the future. The participants will be asked if they wish for their names to be kept anonymous and if they have any reservations about the interview procedure. The interviewee will have access to the question list, which will be linked to the invitation to participate in the interview. This is done to put the interviewee at ease rather than to assess him or her throughout the conversation (Raworth, 2012). At the same time, familiarity with the questions may drive specialists to over-prepare their responses in order to appear more appropriate. If the issue does not come out organically, the interviewer will have an additional question sheet with additional sub-questions to ask.

During the interview process, interviewees will be asked about a situation they are familiar with in which BI may have been beneficial. This assists in contextualizing the subject and, later, in selecting the pilot asset for the implementation of the BI dashboard.

## 5.4 Interview Contents

The Interview questions are divided into three categories. The first category pertains to EFM's strategic decision-making. Candidates will be questioned about AECOM's aims and values when making decisions or recommending solutions to clients, as well as what motivates decision-making inside FMC. Additionally, different sorts of decisions will be explored within the interviewee's domain, and interviewees will be urged to provide actual examples to help materialize the propositions. Following that, candidates will be questioned if the organization has a defined procedure and line of decision-making. Afterwards, participants will be informed about the need to assess the performance of decision-making in order to evaluate the study's hypotheses and then asked about their preferred indicators of decision-making. Finally, the issues inherent in the existing decision-making process are examined.

The second group of interview questions is concerned with business intelligence, dashboards, and their potential uses in decision-making. The participants will be questioned about their knowledge of business intelligence dashboards and whether or not they have any experience with them. Additionally, how frequently they believe BI dashboards are utilized in decision-making at AECOM. Finally, interviewers are questioned about their expectations for a business intelligence dashboard.

The third category particularly asks applicants to describe what they feel would be an appropriate pilot project to apply business intelligence and investigate and assess the benefits of business intelligence in decision-making. This section serves as the foundation for the remainder of the study since it describes the Bi dashboard that will be used to evaluate the ideas.

A Schematic of interview categories and the questions asked in each category can be seen in Figure 5.2

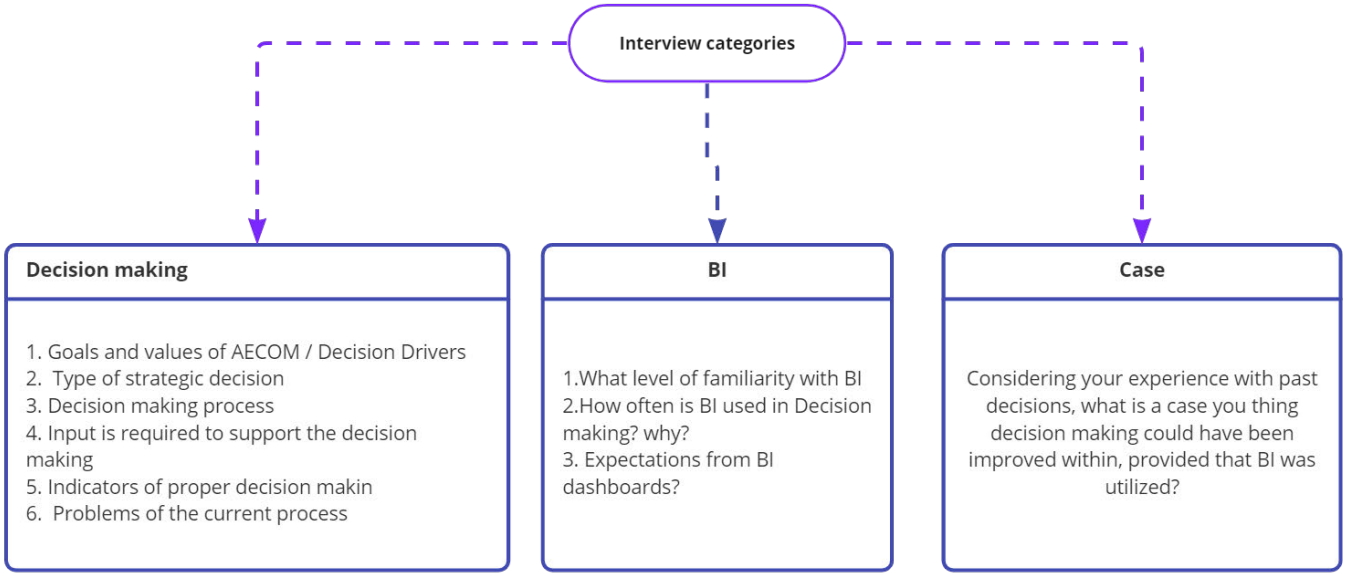


**Figure 5.2 Interview set 1 Category**

# 6 Results

In the first part of this chapter, the Goals and decision drivers of facility management for AECOM will be explained, and afterwards, in the second section, the decisions made within the EFM of filling stations will be classified. This paves the way to identify the input the decision-makers require to make such decisions. These first three parts of chapter six will provide the answer to the second and third research sub-questions. The part of this chapter will explore the expectations from the BI dashboard, which will be used to answer the fifth research sub-question.

## 6.1 Decision-Making Within Facility Management

### Goals And Decision Drivers

Decision drivers refer to the criteria and objectives a person has in mind that dictate which of the available alternatives should be picked while making a decision. In the initial round of interviews, respondents were questioned about their decision-making drivers within their profession. Two of the five respondents, when questioned about the decision drivers, distinguished between decision-making and recommendation making. In most cases, the client will make or approve the final choice on the facilities before it is implemented. However, in time-sensitive instances, the L2 may circumvent the approval procedure and make decisions directly. Although the recommendation-making process is distinct from the decision-making process, particularly in terms of risk-bearing and obligations, both processes share the same line of reasoning with regard to the decision drivers and have the same objectives. Thus, from now on, just the term "decision-making" will be used, but it also encompasses the formulation of recommendations.

Based on the interview, the aims of decision-making from the facility management consultant's perspective are twofold: the goals of the FM firm as a separate entity from the client (AECOM in this example) and the goals and decision drivers with respect to the client.

As the internal objectives of the L2 firm (The FM) may not be related to facility management but have a much broader reach, this research will only investigate the values related to a facility management contract. AECOM's aims include business continuity, quality delivery, and regional expansion (Interviews, 2022).

According to the initial round of interviews, the ultimate objective of FMC is business continuity and value enhancement. To achieve this objective, further sub-goals are established that assist clarify the decision drivers necessary to achieve the ultimate objective. Typically, these sub-goals are inferred by the client as a set of criteria/metrics that the FM firm must meet, and it is the role of the FM company to devise strategies to assist their achievement.

Five out of five (100%) respondents stated that their tactics are geared at exceeding the client-specified criteria that would be presented by AECOM in periodic reports. These criteria, known as the operation's pillars, are Safety and Environment, Finance, Quality and compliance (Contract and Procurement (People), and Operation Status). These interdependent requirements assure the business continuity as a whole. "Safety and environment" or similar phrases such as "HSSE" were featured in each and every response and were specifically underlined by the interviewees. The client determines the requirements of safety and environment and its standards, which translates into the "target zero" for each station, meaning that the goal of AECOM should be to have zero fatal accidents or life-saving rule violations (LSRV) in the future (AECOM Archival data analysis).

Finance, like security, was mentioned in every response. As a general statement, AECOM aims to decrease the client's total cost of ownership (TCO) in financial matters (Several Interview participants, 2022). The total cost of ownership is comprised of the asset's purchase price and its running expenditures. Assessing the total cost of ownership requires a

more comprehensive perspective on the product and its value over time. Obtaining the most value for money, including the best value investments and cost optimization, is one of the primary decision drivers for achieving financial goals. One of the most important aspects of cost optimization is the capitalization of expenditures or lowering Opex and converting it to Capex within a certain budget. Another sub-goal related to finance is increasing the transparency and predictability of the expenditures (Interview participant, 2022). AECOM is obliged to come up with a yearly and also quarterly total cost and revenues

Quality is tied to the notion of business continuity by ensuring that the end users can use the facilities decently and also by checking the permit to operate, ensuring that assets and personnel running the assets have permission to work. The operating permit assures that all essential equipment is in a safe operating condition. People include site personnel and suppliers who visit the site, and they require a particular level of safety and environment to accomplish their duties. In the absence of an operating license for either the assets or the personnel, it is evident that the facility cannot perform its function and produce revenue, jeopardizing company continuity. Enhancing the contract and procurement strategies ensures the determination of Opex and Capex expenditures and is a crucial stage in the establishment of pilot projects. The supplier selection and procurement process have direct effects on other areas, including safety and environment, finances, and job quality. The operation status ensures activities execute smoothly. Two of the interviewees cited system downtime reduction as their decision driver, which is the period when the asset is not performing its intended function and, consequently, generating no money. Figure 6.1 shows an overview of goals and decision drivers in FMC.

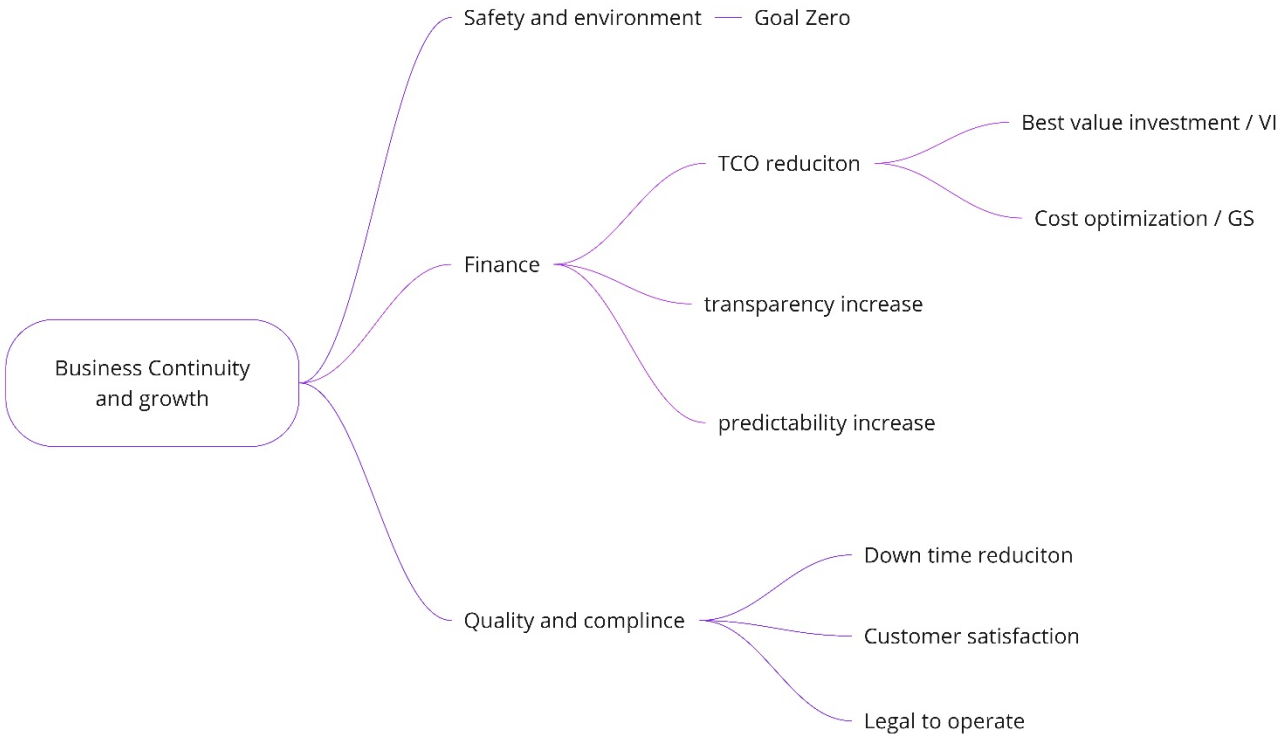


**Figure 6.1 Decision Drivers based on operation pillars**

## Strategic Decisions Typification

Decisions made within FMC generally target two areas: A. Assets and B. people. The Assets are the actual assets existing on the site that are used to provide service to consumers and generate revenue. In the MMS database, more than 50,000 assets are registered (

AECOM archival data analysis). Although every client-owned physical item with the potential economic value might be deemed an asset, not all assets are of equal relevance to the FM firm and may thus be included in the database. What qualifies as a registered asset depends on a number of elements, such as the asset's monetary value, its importance in service delivery, and its maintenance needs (participant observation, 2022). People consist of site personnel, suppliers, contractors, subcontractors, legal entities, client representatives, and AECOM employees, as well as their contractual relationships. Figure 2.1 depicts an overview of the aforementioned contractual relationships. Through the work orders and scheduled activities, the assets and individuals are linked. Work orders are electronic requests made by persons (Site owners or AECOM) regarding an asset that can be reactive or scheduled and sent to other people (contractors or suppliers) that result in a repair, replacement, or removal of the specified asset. Adding a previously non-existent asset typically falls under the purview of EPCM. Figure 7.2 depicts the components and relationships described.

The strategic decisions taken by FMC may be grouped based on the aforementioned categories and their stated objectives. Therefore, the matrix of regions and objectives generates six types of strategic decisions inside FMC:

1. People - Safety: These decisions focus on enhancing safety and environmental practices among L2 and L3 by coercive or incentive activities, such as reflecting safety scores in supplier selection and procurement or providing safety and environment training programmes.

2. Assets – Safety: These choices guarantee that the safety standards for the assets are met. This category includes inspections of critical equipment and their regularity, as well as choices about whether an asset is safe to run or must be modified to prevent dangerous mishaps.

3. People - Finance: All contractual choices pertaining to finance, such as supplier selection, a form of contract (lump money, time and materials, etc.), fees, and budgets, fall under this category. The FM firm will choose the personnel and determine how to collaborate with them to reach financial objectives. Among these decisions falls challenging the prices from contractors.

4. Assets - Finance: The FM firm will choose the sort of asset to purchase, when to repair or replace it, and where to purchase it with an eye to reducing TCO.

5. People - Quality and compliance: The decisions within contract and procurement and the individuals who seek to improve the quality of the job, such as customer and retailer satisfaction or employee contentment with the process. Decisions include escalation protocols and establishing service level agreements (SLAs) with vendors. Currently, AECOM has established five separate SLAs for reactive activities that govern the maximum time a contractor or supplier has to respond to a work order.

6. Assets - Quality and compliance: Asset-related decisions (buy, repair, replace) intended to improve quality and compliance.

Every decision made that falls under one of the above categories should also respect the other goals as the boundaries of decision-making. As an example, while the decision over cascading equipment, which is replacing the equipment in a bigger and more active site and using the old one in a smaller site which generates less revenue, is an Asset – financial decision, it should also respect the safety requirements of the asset and its compliance levels to be used in the new site. (Interview participant, 2022)

Two out of the five interviewees declared the multi-year plan as one of the important areas where decision-making is shown at its peak. A step down from the multi-year plan is the annual plan in which AECOM will predict the T&R and the scheduled tasks for the maintenance and assets to replace under the CM/AI program.

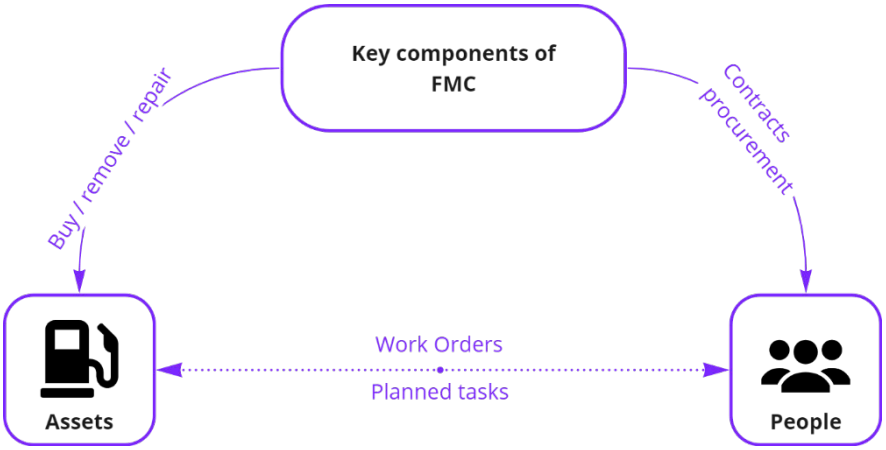


**Figure 6.2 Key components of FMC and their relations**

## Input Required For Decision-Making

Based on the categorization in the previous section, the input requirements fall under the same category as the decisions themselves, which are A. Asset and B. People. These can further break down into the goals of the decisions that need to be made.

The input required for making decisions about the current assets is the age of the assets, the condition of the assets, the work order history of the asset (How often it requires a service), the revenue generated by the asset, the energy consumption of the asset, customer and retailer satisfaction from the asset, asset legal state and etc. When the decision is about to be made for the purchase of the new asset and selection of the model and the vendor, the price of the asset and repair costs (TCO) and environmental impact is also considered (Interview participant, 2022). When making an investment decision over a site, meaning whether or not and how much the client should invest in a site, extra information such as the revenue generated by the site and also the lease terms of the land should also be considered.

In decision regarding the contracts and procurement, information about the costs include the average cost of work orders from a contractor and the type of the contract; Safety information includes Near miss and potential incidents (NMPI), accidents and life-saving rule violations (LSRV) records of the contractors. Quality and compliance information, including the score of the contractor in complying with the legal permits and license to operate and SLA agreements. This information can be represented as the KPI history of the contractor.

Right now, KPIs are used within AECOM. KPIs are broad performance indicators that concentrate on crucial outputs or outcomes. As a performance evaluation method, the KPI is gaining acceptance from a variety of industries. According to Bassioni et al. (2004), 26.4% of the largest construction companies in the United Kingdom employed KPI-related models as performance evaluation frameworks. KPIs can aid managers in concentrating their attention on relatively important performance areas.

In cases with a single input and output, productivity, defined as the ratio of output to input, is an adequate indicator of operational performance. When there are several inputs and various outputs, the analysis becomes more complex.

These numerous inputs might have unique measurement units, and the same could be stated for the numerous output measures. Consider the performance comparison of railway system maintenance. Available kilometres, daily passenger journeys, train stock, and station facilities are examples of inputs. Multiple expenditures consist of O&M expenses per vehicle operating kilometre and car operating kilometre per total staff, including contract hours. (Meng,2011)

AECOM has tracked its HSSE performance via a mix of requirements and key performance indicators (KPI) about the amount of Near-miss/Potential incident reports (NMPI) from suppliers or corporate HSSE officials. The requirements are assessed pass/fail and are declared annually by the customer. The KPI has been rather stable; the client requires a particular number of annual reports to reach 100 per cent KPI. The minimum number fluctuates annually. In certain years, an additional KPI besides NMPIs prompted the elimination of the LSRV report (lifesaving rule violation).

Currently, the FMC's financial success is evaluated by comparing high metrics, such as the total cost and revenues (T&R) and savings. As prerequisites, there is a set of performance indicators, including the on-time delivery of the yearly Capex and Opex estimation and a KPI relating to the per cent decrease in the total cost of ownership. (Farokhi A., 2021)

The interviewees mentioned that currently, the input required for decision-making comes partly from team members' memory based on their experience with the subject, partly comes to form MMS or server and partly is stored decentralized in decision-makers' PC. When an input is required for decision-making, brainstorming sessions are set up in which team members share their information and come up with suggestions based on them.

## Indicators Of Proper Decision-Making

During the interviews, the participants were questioned on how to distinguish between two decisions made by the same decision maker or two decisions made by separate decision makers that are similar to each other. Of the five people who took part in the interview, three of them mentioned the decision outcome as a factor in the evaluation of the decision-making process, and the rest agreed with this concept when it was suggested by the interviewer. They stated that a successful option is one whose outcomes result in better numbers in the FMC operating pillars, as seen in Figure 7.1, than the alternative. Therefore, an enhanced decision is one that contributes more to the growth and continuity of the business, meaning that it is safer and results in higher quality and compliance, as well as greater financial performance. The latter might indicate that it decreases the total cost of ownership (TCO) more or that it is more transparent and predictable in the case of planning.

All of the interviewees agreed that aside from the outcome, the time spent to reach the decision is important. Between two decisions that are the same in their quiddity, the one that is taken faster is considered better. However, it can be discussed that the time spent on decision-making relates to delays in operations, which results in higher system downtime and less revenue generated. This, itself, relates to the outcome and operation pillars. So, it can be discussed that time and outcome are not two independent variables, but that time itself can affect the outcome.

The Interview participant (2022) explained the importance of time in decision-making by setting an example: “When there is work order created with the value above a certain limit, instead of automatically dispatching the order to the pre-define contractor in the system, we can ask for quotes from different contractors. In this case, we can secure better offers and cancel the previous order. The selection of a contractor is time taking and leads to higher system downtime. By implementation of BI, we can take faster decisions with more information, for example, the average cost of work by contractors.”

Interview participant (2022) highlighted the difference between the transactional time required for decision-making and the analytical time required for that. Transactional time is the time the decision requires to go through different layers of organization for approval. She mentioned that due to the lean structure of the company, the transactional

time of decision-making is low enough, especially for long-term decisions and strategic decisions. For operational decisions where you need to analyse data and come up with a decision, As soon as possible, time can be determining factor.

According to Ahmad (2022), the certainty of decision-making should be considered instead of the outcome. “One can only assess the outcome of the decision when a decision is already taken and some time has passed”. This statement is true in highlighting the importance of certainty in decision-making but does not rule out the possibility of using outcomes for assessing the decision, as there are no criteria that limit the assessment to when the decision is being made, but it can happen long after the event. The interviewees were convinced by the argument and supported the fact that this method can be used to evaluate the effect the BI in decision-making in this study.

“Unity in decision-making criteria” and “Decision accuracy” were also suggested by Interview participant (2022) as other indicators of good decision-making. The accuracy can be measured in the long term by the difference between the predicted outcome by means of finance, safety and quality and the real outcome.

## 6.2 BI Experience And Expectations

All of the participants claimed to be familiar with BI, but follow-up questions indicated that their knowledge was limited to BI dashboards and not to BI as the entire process encompassing need identification, data collecting, and decision-making. "As a dashboard user, I am familiar with BI dashboards, but not as a dashboard designer”, said The project controller during the interviews.

All interviewees stated that BI dashboards are only utilized for client reporting and SLA monitoring. When asked why BI dashboards are not being utilized for decision-making and suggestion-making beyond client reports, one respondent cited the inadequate database and the fact that the database could not be trusted. Another respondent stated that Excel sheets are the standard method of working with data at AECOM and that everyone is accustomed to using them. Consequently, BI dashboards are not yet widely regarded as a replacement.

Three of the participants mentioned that they expect the BI dashboards to provide a visual experience. One of these participants (The Interview participant) identified "trendlines" as the graphical output he expected from the dashboard. "FMC processes a vast amount of data, and there are various minute aspects to consider while making decisions. I think that BI will enable us to assess a bigger number of decision-making elements by providing a visual report that is both clear and integrated.”

Time was cited as an expectation by two of the respondents. Time was portrayed in two distinct ways: A. As the speed of information availability and improvement in the time necessary for decision-making, and B. as the decision horizon, which refers to the timeframe AECOM takes into account while making judgments within FMC. Interview participant, G., described these two opposing viewpoints as "With BI, we should have shorter decision-making time and longer analysis periods.”

Interview participant anticipated BI to serve as an overall link across various facilities management divisions. The information given by BI dashboards should represent impending plans from many departments so that decision-making in diverse sectors is more consistent, resulting in decreased costs and site downtime. For instance, Interview participant noted that he likes to examine the building plans that other parties may have for a future location so that he may align the CM/AI plans with them. Thus, the site will be closed just once, and some of the work can be performed concurrently.

Another expectation that emerged from the interviews was that the interface would be simple. The respondents contrasted BI dashboards to the charts and tables offered by Excel and noted that Excel sheets are somewhat difficult to manipulate; Interview participant added: “Power BI, or anything, it needs to be usable now and, in the future, that

it's future proof, and that it's straightforward. And that we show data in a highly attractive manner because spreadsheets are terrible." As noted in this quotation, BI is also evaluated in terms of the time and resources required for its implementation. Interview participant anticipated that the BI dashboards would be future-proof in order to justify the costs expended.

The overview of the BI expectations can be found in the table below:

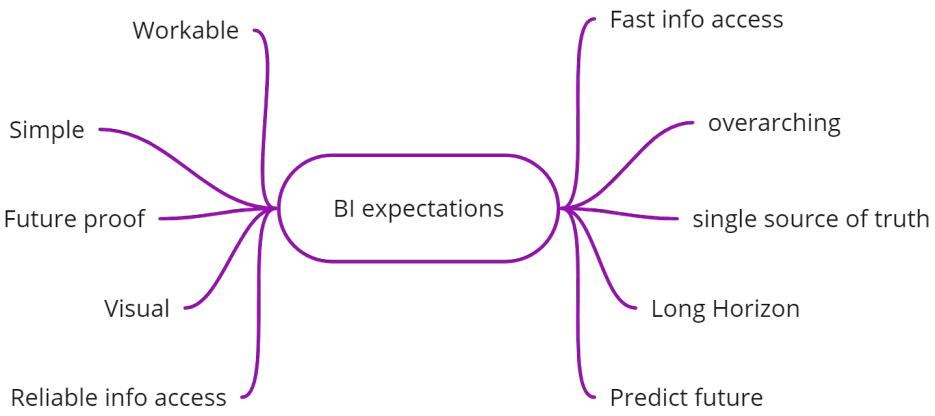


**Figure 6.3 Expectations from BI, based on interviews, 2022**

## 6.3 Selection of a case for the pilot dashboard

During the course of the interviews, the interviewees were asked about their suggestions for the pilot dashboard. The goal of the pilot was to solidify the findings of the research. The results indicated the criteria of a good case for the pilot project to be as follows:

- The case should be able to engage different aspects of the decision-making drivers and goals of the operation pillars of the FMC (Figure 6.1 Decision Drivers based on operation pillars)
- The case should be able to demonstrate the change in the decision-making performance indicators discussed in the section "Indicators of proper decision-making."
- The case should be feasible. To be able to produce the dashboards, it is better to focus on the cases where there is already sufficient data within the AECOM database.
- Due to the limitation of this study in time and resources, it is better to select a case that is not too complicated. The cases that involve many different stakeholders and too much-scattered data drive the study away from its initial goal, which is evaluating the value of BI application within FM.
- The case is preferably impactful (involves high revenue)

The interviewees seemed to be interested only in their own scope of work. The proposed suggestions by each of the interviewees were usually about what they have been working on within their work recently. In total, five different cases within FMC were proposed. Each of the five suggestions is reviewed based on the criteria mentioned above, and the final case will be selected afterwards.

## Case 1: Fuel contractor

Fuel contractor is the largest L3 contractor that handles the majority of fuel and LNG work orders. Their employment in fuel covers 74 per cent of the overall risk-linked work orders, and 70 per cent of the risk-related duties they execute entail dealing with Fuel (Figure 7.4). As Fuel contractor has one of the biggest contracts and their employment also contains a considerable number of safety concerns, they might be an excellent choice for completing data analysis. Interview participant offered to construct a BI dashboard which represents Fuel contractor performance in different elements of safety, quality (SLAs) and money. Performing an analysis on Fuel contractor assists in decision-making on future contractual agreements.

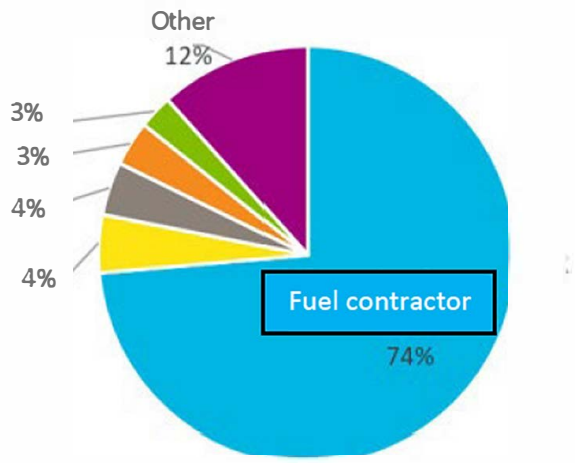


Figure 6.4 Share of companies in performing the risk-related work

## Case 2: Refrigeration contractor contract

Choosing the contract type for the Refrigeration contractor BV. It is a strategic choice that requires a lot of data. There are two contract choices on the table: Lumpsum and cost-reimbursable. BI should assist AECOM in establishing the greatest value contract type considering the pricing, but this is not the only criterion that should be examined. Interview participant mentioned that aside from the pricing, we should be able to check other aspects of the operating pillars that may be influenced as well: "Refrigeration contractor refrigeration is probably the major one that springs to mind. So, as you know, we've said, OK, we'll go from lumpsum to break repair. But, other than the price, what else has changed? The pricing is subject to change. Did your performance improve? Did the usage of spare components affect anything the first time? What should be changed? Is there anything else that changed when we shifted from one sort of contract to another outside the cost?"

## Case 3: CM/AI replacement program

As mentioned earlier, CM/AI program focuses on replacing the assets that have reached their service time or seem to be functioning inefficiently. For example, the HVAC program was proposed because of its large income, its great influence on the company continuity and the availability of Data. If HVAC is damaged, the clients will avoid entering the shops or would spend less time in it, which will limit the money made. The HVAC program, as well as other CM/AI programs, also has a fair amount of safety problems involved. In the CM/AI program, right now, the replacement of the assets is dependent on their age. Interview participant mentioned that although the Goal of AECOM is that in the future, other elements aside from age will be utilized to determine the replacement time of the assets, right now, we can focus on utilizing BI dashboards to have an overview of the assets that are going to be replaced in the approaching year. Therefore, we would probably observe that in some years, there is a high number of assets that require

replacement altogether, and in years we would have only a handful. If we had access to this perspective, then we would be able to “flatten the curve”, therefore, dispersing the workload.

## Case 4: Cancelled work orders due to quote requests

AECOM has created a policy for reactive work orders that prevent contractors from doing reactive jobs over a certain quantity. In this scenario, there is an additional stage in the job approval procedure that the contractor should first submit a quotation, and then the quote should be accepted by AECOM. This approach introduces a delay in the repair process in the way that first, the AECOM maintenance leaders need first determine whether they first want bids from other contractors or not and which firms to contact. The sooner they have access to information about the typical cost of work orders, or the cost of the identical works, the safety performance of the contractor and their SLAs, the simpler they can determine whether they want to cancel the present order and put it on another contractor or not. By lowering the decision-making time, BI can assist decrease the downtime, and by generating better quotations, they can save lots of money for the customer. In the end, by having an overview of all the cancelled and replaced work orders, they can present the customer with the overall savings they have brought.

## Case 5: T&R estimation

Every year AECOM needs to present an expected T&R to the client for budget allocation. Aside from the yearly T&R, AECOM also gives weekly T&R analysis. This T&R gets regularly updated as time goes by based on the costs previously transpired and tasks planned. The monthly T&R is normally made by dividing the total T&R by twelve months. By employing BI dashboards, AECOM will be able to anticipate the real T&R spread across the year, which implies the T&R may be lower in certain months and greater in others. In this manner, when comparing the actual expenditures with the expected T&R, AECOM can become more definite in deciding whether they are overspending or underspending and how to rectify that.

## The Chosen case

In order to pick the best choice for the pilot project, a weighted criterion analysis based on the criteria listed in section 7.3 was conducted. The score was based on the subjective opinions of the author, which were supported by expert interviews. For this investigation, a weighted score between one and five was chosen. Five indicates that the criterion has the most influence on case selection. The scores adhere to the same rationale, with one being the lowest and five being the lowest.

The most weight was given to the feasibility criterion since the absence of data and substructure would result in the project's failure or excessive delays. AECOM has neither the ambition nor the means to devote time and money to creating BI needs beyond the existing investment with a defined scope (Solis, M). As a consequence, it was determined that it is better to base the work on the resources now available.

Complexity and implied policy closely resemble the feasibility criteria but differ in that it is not about the availability of resources and substructure but rather the analytical complexities required to comprehend the data, and in some cases, the client may have a preference for a particular party due to the history of the stakeholders or the impact of other projects. Therefore, the decision-making process in this instance may not follow the predicted route based on the stated criteria. However, these issues do not indicate an unmanageable burden that would lead to the failure of the study and may be circumvented by workarounds. Consequently, they have been given far less weight than practicality.

The Impact criterion also received the lowest weight in the table, which is due to the fact that the impact of the project, which is frequently measured by the project's related revenue, is only a concern for AECOM, as they seek to maximize the return on their investments, and in this case, the BI is viewed as a project that can result in cost savings and has

financial value. However, from an academic standpoint, the impact on income is of little consequence as we wish to test the hypothesis itself. Therefore, it has been assigned a lesser weight.

Collectiveness and the case's capacity to demonstrate changes in the decision-making process are of great importance in this research and play a significant part in this case. However, they can only produce what is expected of them if the project is initially created, resulting in a lower score than the feasibility criterion but a better score than other criteria.

| Criteria | weight | Case 1: Supplier Investigation | | Case 2: Contr investigation. | | Case 3: CM/AI replacement program | | Case 4: Cancelled work orders due to quote requests | |
|---|---|---|---|---|---|---|---|---|---|
| | | raw score | weighted score | raw score | weighted score | raw score | weighted score | raw score | weighted score |
| Collectivity: Including different pillars of decision making drivers | 4 | 5 | 20 | 5 | 20 | 4 | 16 | 3 | 12 |
| Indicates measurable changes in the indicators of proper decision making | 4 | 2 | 8 | 4 | 16 | 5 | 20 | 4 | 16 |
| Feasibility: Access to data, knowledge of BI processes and dashboards | 5 | 3 | 15 | 3 | 15 | 5 | 25 | 3 | 15 |
| Complexity and implied policy | 3 | 2 | 6 | 3 | 9 | 5 | 15 | 4 | 12 |
| Impact: Includes a large scope | 3 | 5 | 15 | 4 | 12 | 4 | 12 | 5 | 15 |
| | **22** | | **64** | | **72** | | **88** | | **70** |

**Figure 6.5 Weighted criteria analysis for decision-making**

After describing the logic for the distribution of weights, it is now time to examine the cases in further detail to see how they measure up against these criteria. The first instance involves the creation of a dashboard that provides an overview of a given supplier's performance across many operation pillars and key performance indicators (KPIs) in place. Depending on the breadth of the supplier's work, the outcomes may vary. In this instance, respondents recommended Fuel contractor as the largest contractor/supplier with whom the customer is under contract. This example has a high grade for collectivity since its safety, quality, and financial performance can be evaluated. However, this does not immediately relate to decision-making, and the presented knowledge does not directly affect a decision that has been made or needs to be made right now, but it will be useful for forthcoming difficulties that are currently unknown. This dashboard will mostly be used to monitor the supplier's performance and is not necessary to make strategic choices. In addition, due to the client's political ties, suppliers and contractors are difficult to engage with. As a result, its scores on the second and fourth criterion poorly. Periodically published MMS data and KPI provide sufficient access to information. The impact can potentially be significant, especially when a large provider is chosen.

The second instance is pretty similar to the first in that it focuses on a provider, but this time the objective is to choose the optimal contract type. The dashboard can be beneficial for evaluating the impact of a choice since it displays historical data alongside current performance metrics. It also encompasses a variety of facets, with money being the most prominent. The disadvantage of this scenario may be its complexity since the selection of the contract type depends on a large number of variables and requires some time to demonstrate its effects on the project. Furthermore, because AECOM keeps far less information regarding fixed-price contracts, there are less data accessible.

The CM/AI software is the third instance. The choice of what should be replaced and when and what should be acquired heavily involves the pillars of decision-making. The type of asset that is acquired and whether it has developed adequate safety standards, for instance, might endanger the lives of its users. It is also connected to the quality and compliance of the asset itself, and its functionality can affect the user experience. This instance is likewise quite costly, and it has a dedicated budget. A change in the replacement date or the model might have a significant influence on the client's costs and result in cost savings. The repercussions of decision-making are relatively straightforward to quantify, particularly in the financial sector. Consequently, this instance received a very high score for the first criterion. This case also obtained the best score for the third criterion, as it is connected with AECOM's existing BI initiatives making resources available from those projects. The CM/AI case can be case-specific, focused on a single program such as the HVAC program, or Carwash, allowing the dashboard to be modified for any program, making it incredibly powerful and influential.

The difficulty with the fourth instance is that it is overly focused on operational decision-making rather than strategic decision-making and is also limited to financial drivers. However, measuring the impact of dashboards on the client's cost reductions is an excellent topic. Additionally, the amount of money saved is substantial, resulting in a significant effect (The Interview participant 2022). Because the analysis procedure is dependent on the maintenance lead and is conducted by telephone with the suppliers, specific MMS data might be missing or impossible to read, resulting in a lower score.

Based on the above reasoning, the CM/AI program case was selected for this study. An Additional interview was conducted with the CM/AI operations director to investigate the team's needs that they expect to see on the dashboards.

# 7 The Pilot Dashboard

In this chapter, the development phases of the BI dashboard based on the selected scenario will be described, along with an illustration of the dashboard's environment. This chapter illustrates the final appearance and potential functionality of the BI dashboards.

The development of the CM/AI dashboard consists mostly of four steps: 1- Data collection and alteration 2- Selection of a commercially available dashboard tool 3- Creation of a data model 4- Creation of the interface.

## 7.1 Data Collection And Alteration

The data required for this dashboard was identified based on the chapter “Input required for decision-making” (Page 43). Most of the data were exported as excel files directly from the MMS, and the rest were provided by the data team. Although the final goal of this type of dashboard is to be connected to the data server so that the data get updated in real-time, it was decided to import the data manually to be able to work offline. Working offline means that the whole dashboard could be run from a personal computer, eliminating the need to access the MMS APIs, which would otherwise require extra permissions from Urgent and extra time and energy for the programming. As this dashboard is intended to be used for strategic decision-making and not for operational decision-making or controlling, there is no necessity to update the data in very short intervals, making this type of information access justifiable.

All the data were uploaded to the TUDelft OneDrive folder with restricted access. This way, the data can be accessed in case of need for auditing, but at the same time bans unauthorized data access. The fact neither the data nor the dashboard is stored directly on personal computers ensures the privacy of the client and AECOM.

In total, eight excel files were used for the creation of this study. Information regarding these files is as below:

1- The biggest data file was “Asset data” taken from MMS, which contains information on all of the assets that are registered in the system. This information includes but does not limit to their Asset matrix item (Which is an internal cascading way of defining the asset type), the asset model and manufacturer, their location and also information about the asset seller and maintenance provider.
2- Work order details. The second file provided information about all of the work orders that have been ever created in the system. The most important information from this file that was used in this study was the work order “repair matrix” (Which is an internal cascading way of showing the work order type), the location, the date of the work order creation, and also the supplier detail which handled the work.
3- Invoice details. As the name suggests, this file is used to extract financial numbers regarding the tasks performed so far.
4- The fourth file contains information about the “landlord clauses”, such as the lease terms and the state of the ownership of the site.
5- Actual outlet. This file is updated regularly by the client and shows the newest information about the active sites and their address details.
6- HSSE data. All of the HSSE reports recorded so far are present in this file. They include information about the seriousness of the incident, the responsible party, the location and the date of the incident.
7- PU43 strategy. This file which is also taken directly from the client gives an overview of the categorization of the sites based on the client's criteria. The sites have different priorities, and this is important for planning the investments. Based on the aforementioned categorization, a site can be a destination, a focus location or a

performing NWH. Also, The sites can be categorized based on their location, to a highway or a non-highway. More information about each category can be found in Appendix C.

8- Roof-mounted plant. This data gives specific information about the presence of assets at a height.

## 7.2 Dashboard Tools

In this part, the technology used to build the BI reports will be discussed, and an overview of the market's main BI tools will be provided. At the time of writing this article, there are a dozen commercially accessible BI tools that enable users to create dynamic data representations. Using these technologies, data discovery, which was formerly exclusive to sophisticated analytics professionals, is now accessible to everyone. In addition, these technologies provide the insights you need to accomplish growth, handle pressing concerns, aggregate all your data in one location, predict future events, and so much more. Some of the most popular BI tools are as follow (Masmoudi, 2022):

### DataStudio

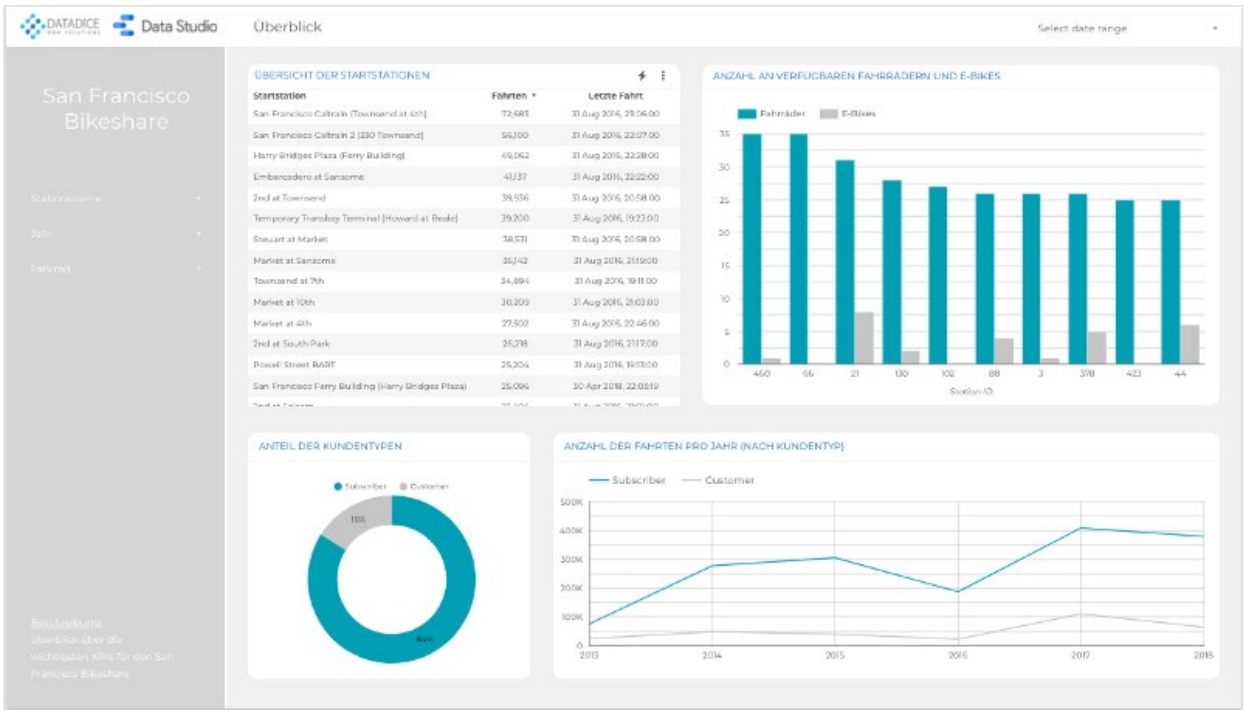


**Figure 7.1 DataStudio interface, https://datastudio.google.com/ (Powered by datadice)**

DataStudio is a popular dashboarding application that is included in the Google Cloud toolset. With its user-friendly features and native implementations of Google's many services, Google is reducing the gap with the market's major rivals. DataStudio provides a great deal of flexibility with the incorporation of third-party tools and the various options for manipulating imported charts and data.

*Key Features*

- Intuitive drag-and-drop interface: Drag and drop your KPIs into the interface to create a professional dashboard without the need for significant coding knowledge.
- Interactive dashboard capabilities: advanced dashboard capabilities such as drill-downs and hierarchical filters.
- You may embed DataStudio into your own application, share reports by URL, or embed iframes on your website.
- Customized templates: DataStudio allows you to design templates for your dashboards by setting the colour accent and chart attributes in order to generate reports with a consistent theme.
- Native integrations: DataStudio is highly effective when it comes to the direct and simple usage of Google's other services, such as Big Query for data warehousing and Google Analytics for user activity tracking.

*Shortcomings*

The drag-and-drop interface for charts and rapid alignments is not intuitive. And data studio does not offer a mobile version. In addition, DataStudio does not provide any prediction tools.

## Looker

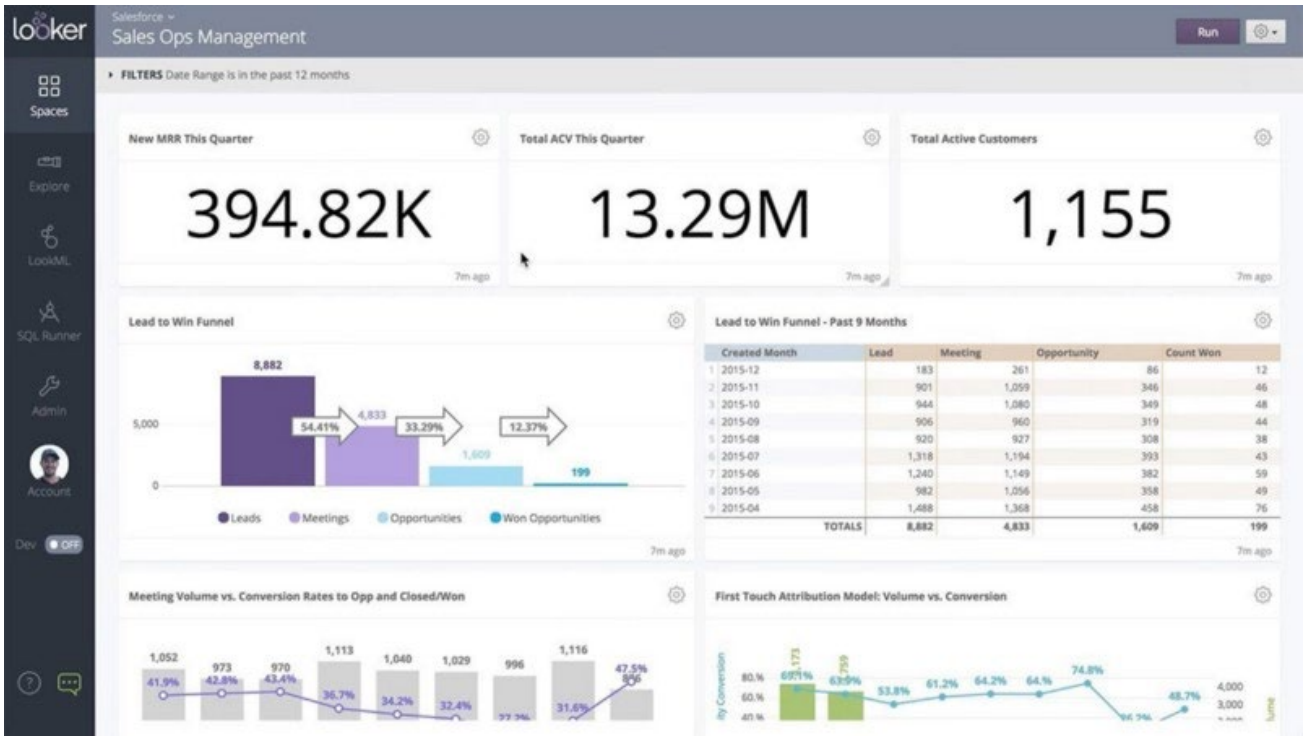


**Figure 7.2 Looker interface, https://looker.com/**

Looker, which was recently bought by Google, goes beyond BI to assist organizations in delivering impact through data experiences tailored to how people work. This technology fits easily into company operations, interfaces with third-party systems, and allows businesses to develop their own data applications. All while providing business intelligence capabilities of the highest calibre.

*Key Attributes*

- Looker provides a version-controlled modelling layer that enables analysts to specify their business logic and iterate on that business logic in a version-controlled manner.
- Looker's design makes use of the inherent scalability and performance of current cloud databases. Looker, unlike the majority of its rivals, does not rely on outdated data extracts or a proprietary in-memory design that compels you to guess the questions your customers will ask.
- Looker is renowned for its live customer assistance, which enables its consumers to escape the technical support backlog.

*Shortcomings*

Due to its recent introduction to the market, Looker has room for development in terms of dashboard customization. In addition, it has a steeper learning curve for users due to the introduction of new ideas compared to other tools, and its cost structure is not suitable for modest budget projects.

# Datapine

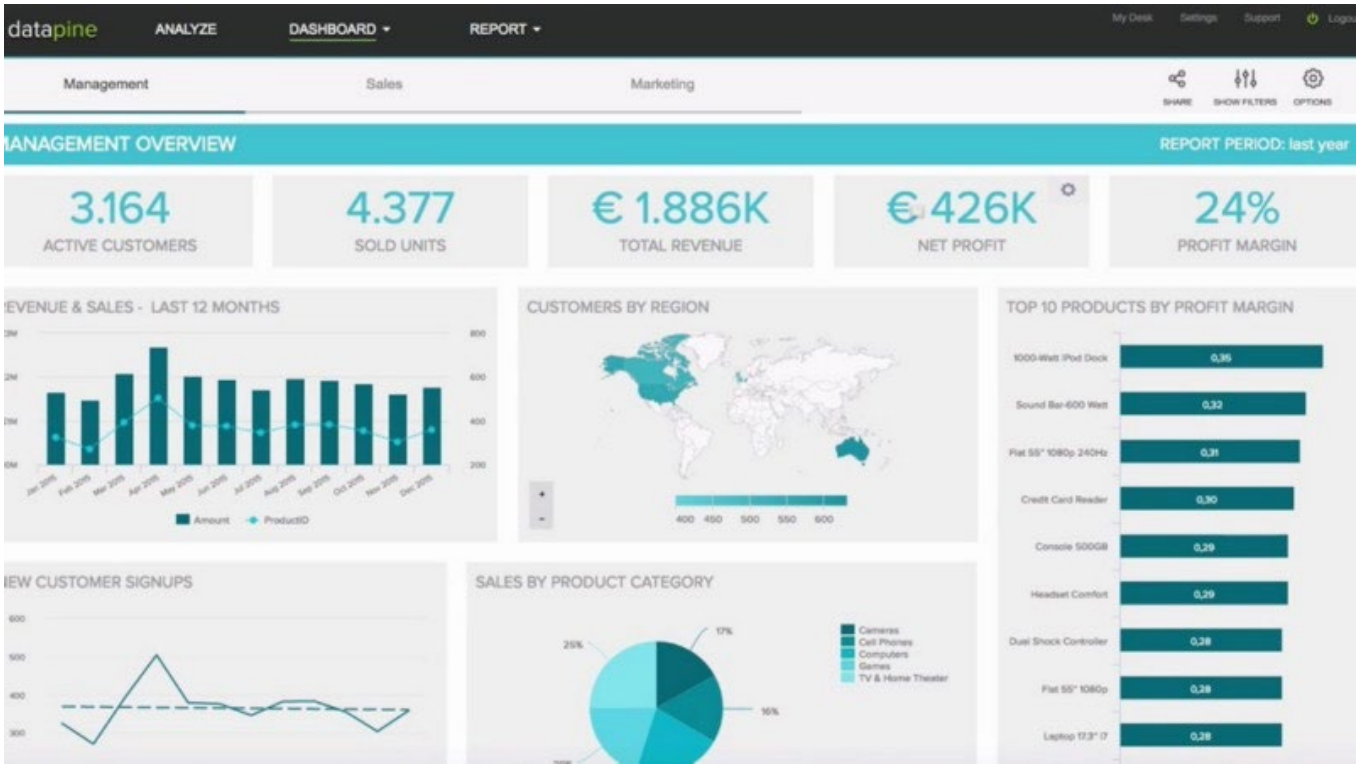


**Figure 7.3 Datapine interface, https://www.datapine.com/**

Datapine is a well-known BI software for sophisticated analyses that connect to several data sources. With this application, you can generate a robust company dashboard, individualized reports, and even alerts for anomalies or specified objectives. Datapine's SQL mode allows analysts to design their own queries. And with its drag-and-drop interface, it provides business users with a visually easy method for entering information and building effective charts and dashboards.

*Key Attributes*

- Analytics predictive of use: Tools for advanced analysis that incorporate predictive analysis based on a prediction engine. You simply need to choose the indicator, the amount of forecast data points, and the model quality (confidence interval).
- You may integrate Datapine inside your own program, distribute reports through URL, enable viewer access, and send automatic e-mail reports.
- AI-based smart insights and alerts: You may configure your dashboard to produce several sorts of insights, such as growth, trends, value drivers, and conditional scenarios, and to warn you of abnormalities.

*Shortcomings*

The mobile view functionality is limited to the Datapine app, and you must customize the mobile view independently.

# Power BI

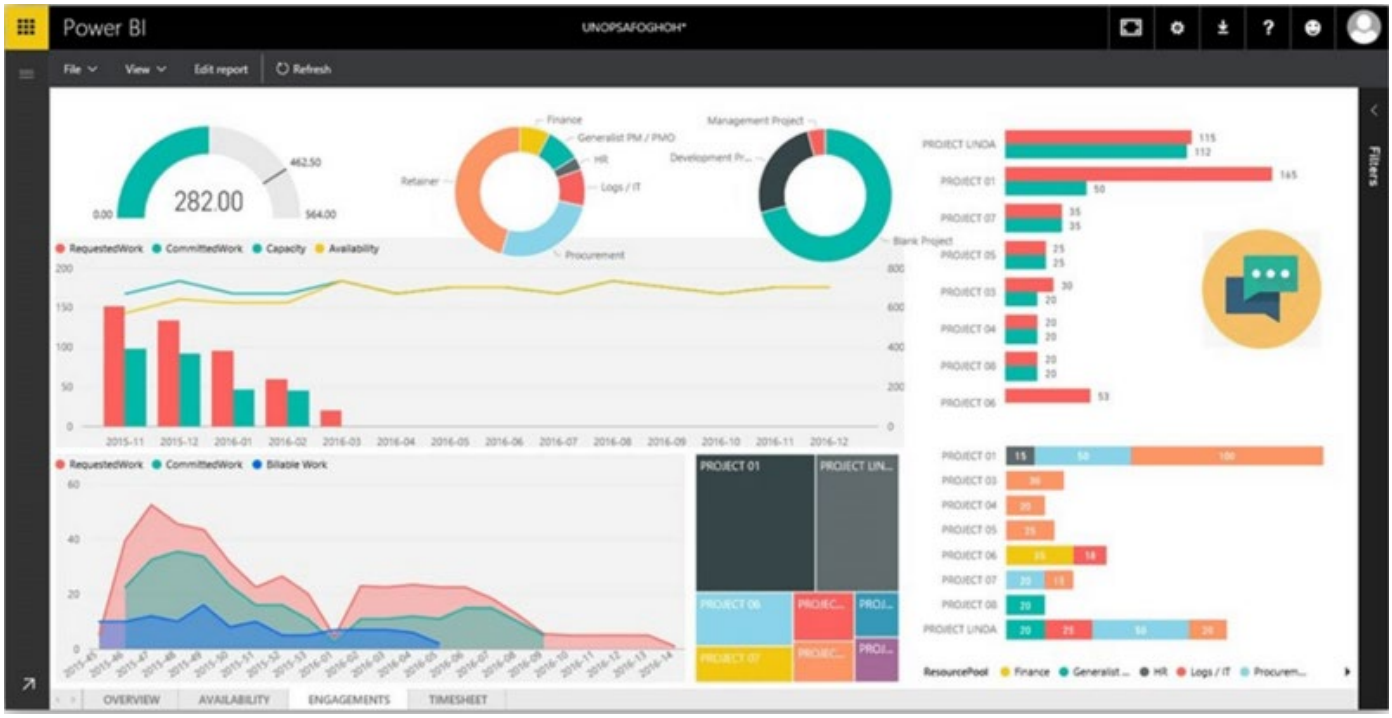


**Figure 7.4 Power BI interface, https://powerbi.microsoft.com/**

Microsoft's Power BI is a data visualization tool designed to complement its numerous analytic capabilities. Power BI provides several potent capabilities and numerous integration options with various data sources. This tool allows the user to establish new dimensions and relationships between tables without the requirement for a separate tool.

*Key Attributes*

- Brief information summary: Accessibility to data exploration that enables users to make increasingly educated decisions in response to business requirements.
- Refreshing data: Regarding the fact that not all data sources allow real-time querying, Power BI includes a tool that automatically refreshes your dashboards numerous times per day, based on business-specific parameters.
- Universal platform accessibility: In contrast to the majority of other solutions, Power BI has an exporting function that supports not just embedded web apps but also mobile platforms such as Android, IOS, and Windows.
- Power BI offers two versions that vary in price: Power BI Pro and Power BI Premium. The entry-level offering is Power BI Pro, which provides full Azure cloud features at a reasonable cost per user per month.

*Shortcomings*

Reduced layout customization options for the integrated charts might frustrate users with specialized needs.

# Tableau

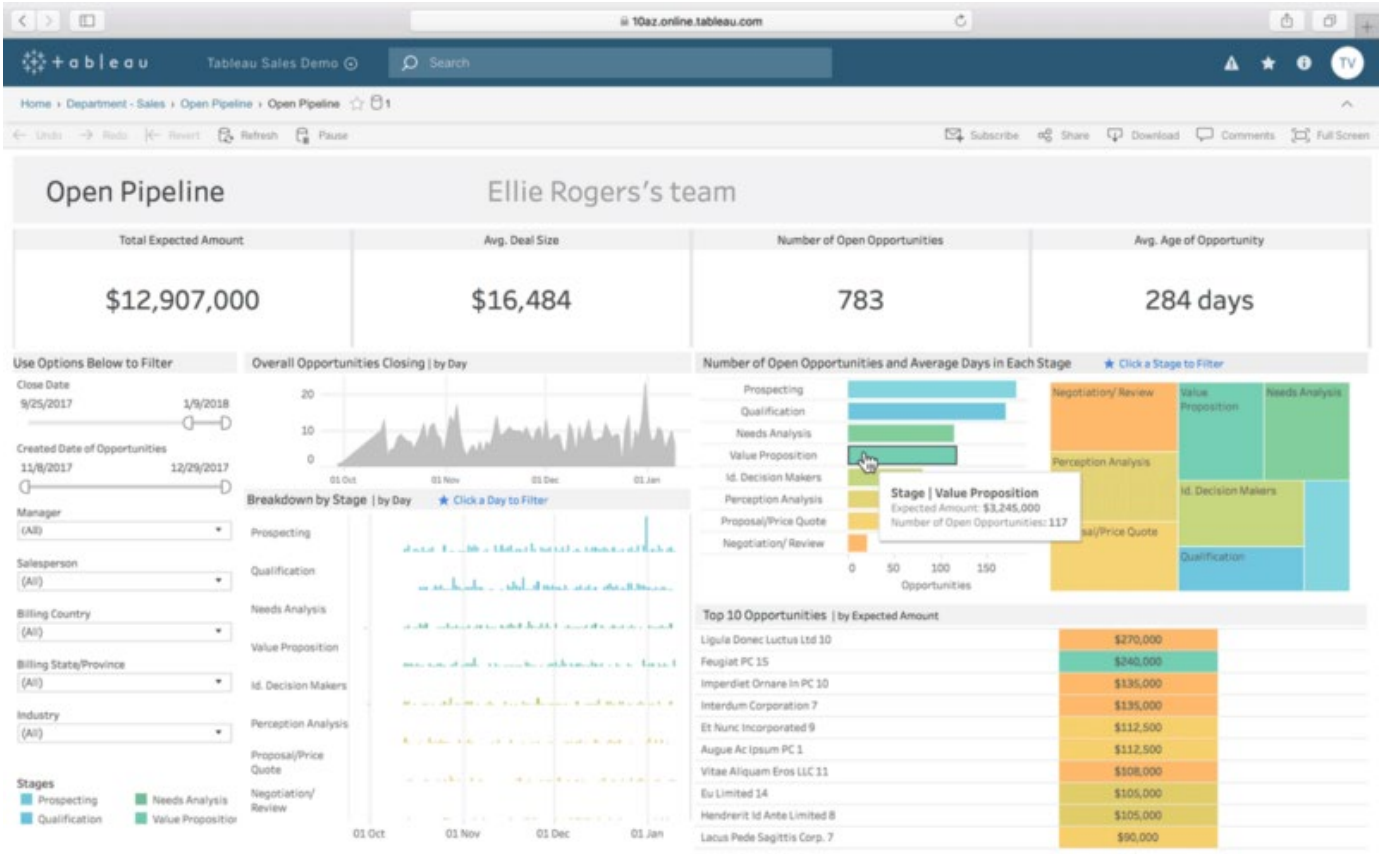


**Figure 7.5 Tableau interface, https://www.tableau.com/**

Tableau is a fashionable BI solution that many firms are using, and it is distinctive for its Pixar-powered visuals and design. Tableau has been around for over 16 years and distinguishes out for the user experience it provides. Even novices will not have a frustrating initial encounter with it.

*Key Attributes*

- Tableau has remarkable visualisation skills; it transforms unstructured statistical data into fully functioning, interactive, and visually attractive dashboards with many sorts of visuals.
- Tableau is distinguished by its robust and dependable performance. This tool is faster on large data sets than other popular tools.
- Business users may expand their understanding of data processing and reporting and get numerous important insights thanks to Tableau's thriving network of professionals and businesses.
- Compatibility with mobile devices: Tableau offers an efficient mobile app for IOS and Android that delivers the same capabilities as the Desktop and Online editions.

*Shortcomings*

Tableau's inability to give its consumers a case-by-case approach is a deficiency. Therefore, regardless of their demands, all businesses must obtain an extended license from the outset.

### Selected Dashboard

With a variety of tools on the market, each firm adopts the one that best meets its requirements and needs. “We can observe that many firms are switching between these tools more frequently, which may be attributed to the fierce competition between them and the rapid enhancements and new features made by each of these BI systems.” (Masmoudi, 2022). Regardless of the company's core design, the future leans toward the tools with the most third-party integrations, the services they provide, and their integration with cloud solutions. **Cross-platform solutions** and **the capacity for analyst collaboration** are now major market benefits. Customers are dissatisfied with conventional solutions when they may have a dashboard that is tailored to their needs and meets their individual criteria. Pricing can also be significant since organizations are increasingly keeping enormous volumes of data, which might increase their monthly expenses if decision-makers choose an improper reporting solution.

Microsoft Power BI was selected in this study to create the reports because Power BI offers a unique cross-platform solution specifically aligned with other Microsoft products that have been widely used by the large firm for their hybrid collaboration work style. AECOM has been relying on Microsoft software solutions both for document creation and management and for online collaboration. Hence, Power BI becomes a suitable option due to its integration with other Microsoft products. Moreover, Power BI uses the same design language that was previously used by other Microsoft services like excel, making it easier to comprehend by the employees who will be using it, offering an easier start.

## 7.3 Creation Of A Data Model

The next step after selecting the proper BI tool is connecting the data with the dashboard and creating the data model. One of the most important steps in the creation of this model is defining the relationships between the data sets. When many tables are imported, it is likely that analysis will be performed utilizing data from each table. Relationships between these tables are essential for correctly calculating results and displaying accurate data in reports. Power BI Model Relationships propagate column-level filters from one model table to another. As long as there is a relational route to follow, which might encompass many tables, filters will propagate. Along the relationship pathways, filters are always propagated in the same manner and without random fluctuation. Nonetheless, model computations that employ particular DAX functions can deactivate relationships or alter their filter context. Power BI model relationships do not ensure data integrity.

A key step in designing the Power BI relations is defining a column that is the link between different tables. If this column is not directly available, it needs to be created. As the focus of the CM/AI dashboard is the planning of replacement programs per site, meaning that the final decision would be a list of sites where a replacement will take place on a specific date, the column that includes the site's unique identifiers was selected as the linking column. This column is named “NL_Number” in every table. As mentioned in chapter “Data collection and alteration”, the latest list of Nl_Numbers is available in the “Actual outlet” list provided by the client.

As seen in Figure 7.6, Data relationships within the CM/AI dashboard, every table is connected to the Actual outlet list except for the Task summary, which is connected to the Invoice details. While the site identifier is a unique value in the Actual outlet table, it is not necessarily unique in the other table. Thus the connection type can be either one-to-one or one-to-many.

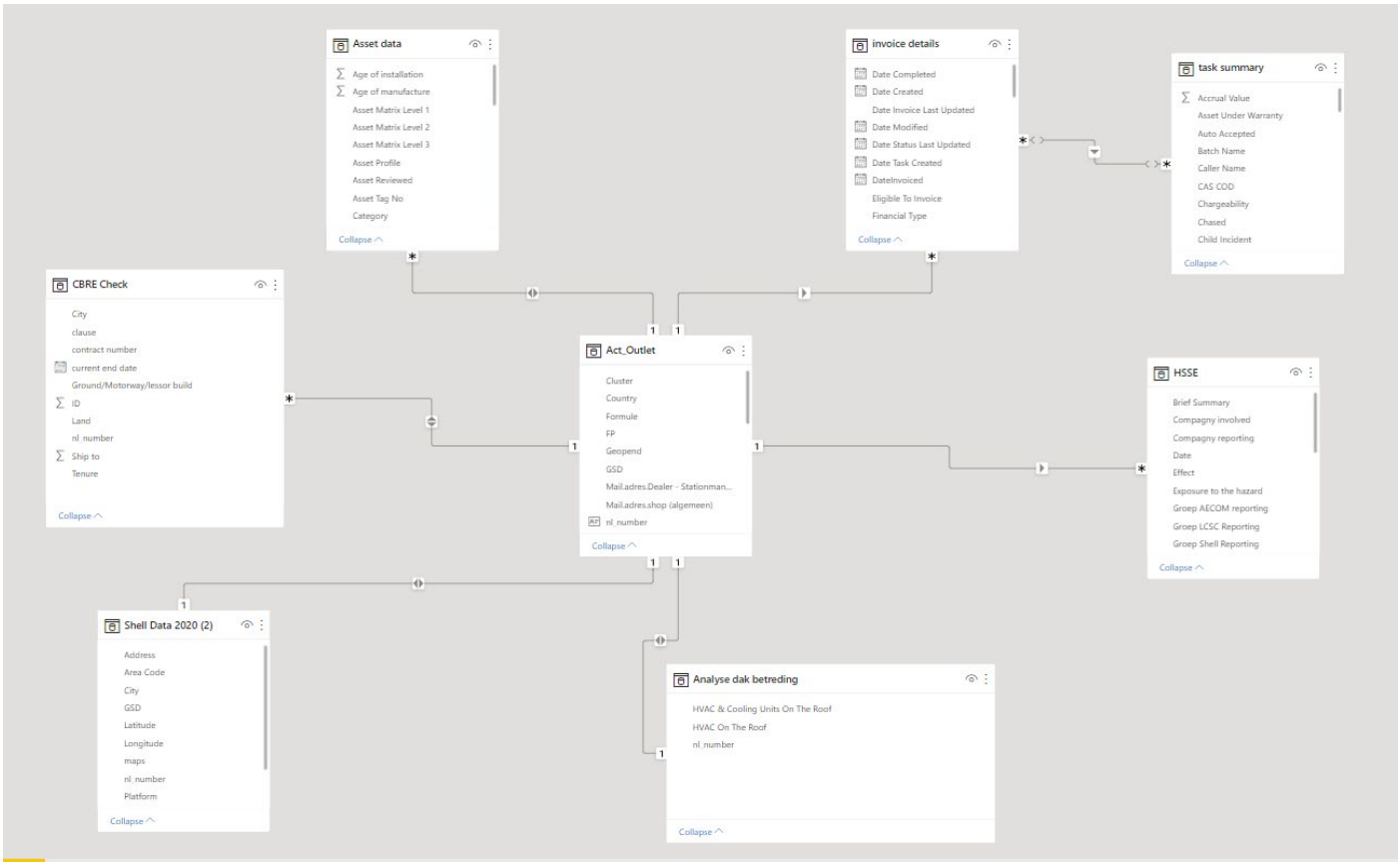


**Figure 7.6 Data relationships within the CM/AI dashboard**

## 7.4 Creation Of The Interface

The dashboard was developed based on the findings of the interviews and using an iterative approach by which the primary dashboard would be presented to the CM/AI program manager and a member of the data team, and based on their feedback, the design would be matured. This continued until no further comments were made by them. When building the interface, it was envisioned that the dashboard would appear straightforward and contain only the data required for decision-making in CM/AI projects. Thus, a tiered interface was constructed using the drill-through capability of Power BI. The drill through function in Power BI allows you to select a value in a visual and navigate to a new page with the value's information. It's a terrific approach to navigating a report because you can quickly jump to a page holding the information that interests you.

### Main Page

The main page of the dashboard gives an overview of the sites explained per different criteria. The goal of the design was to give the users the ability to identify the sites which need replacement. There are several slicers in place to limit the scope of the work. The users can select the priority type of the site as described in the PU43 strategy (see page 51) and also the program. The predefined program is HVAC, Car care, EV and CCTV.

The age of the assets is one of the most crucial decision-making variables in asset integrity programs. On the dashboard's home page, the user can pick the asset age range to be considered in the visualizations. One of the visualizations displays a benchmark based on the average age of the sites' assets. This allows the user to quickly identify the number of the oldest sites.

The second graphic depicts expenditures per site. One of the other major decisive variables for the CM/AI program is the expenditures. In the user interface, users can select the spending category (Opex, Capex, CM/AI Capex) and the year they wish to view.

In addition to age and expense, safety reports are another consideration that can impact which sites are selected for the replacement program. This is the first time that project managers are able to evaluate HSSE data alongside other elements that they typically consider when making decisions, as shown by interviews. To be able to see the connection between age, expenditure and safety hazards, a three-dimensional graph has been produced with two axes being age and expenditure and the third axes being the number of incidents per site shown by circles. The size and colour of the circles show the frequency of the report. Figure 7.7 shows the main page of the CM/AI dashboard as described.

After identifying the initial sites, users can use the drill-through function to go to a detailed overview of the data. There are three drill-through pages designed in total: A- Site detail, B- Work order detail and C- Safety detail.

## Site Details

In contrast to the homepage, which provides an overview of many sites, the site detail page concentrates on a single site and provides extensive information about it, including the site manager's name, identification number, address, and contact information. In addition, the dashboard contains a map that displays the site's location, and users can click on the map to view a virtual tour of the site. This feature enables users to rapidly access a wealth of site-specific information that would otherwise need a physical visit.

In addition to the previously mentioned information, users can view a list of the site's assets, filtered by their program of interest. For example, if the user selects the HVAC program, he or she will be able to view all HVAC assets, such as boilers, condensers, and split units.

In addition to the aforementioned details, viewers can view the site's ownership status and, if the site is rented, the lease expiration date at the top of the page. This prevents investments in places that will shortly be abandoned. In this feature, customers may also view the annual expenses of a specific site. Figure 7.8 illustrates the site detail page.

## Work Orders Detail

On this page, information about the distribution of the work orders can be found. The treemap shows the quantity of the work orders based on their repair matrix item. So that the users can see which items have required maintenance more frequently; also, information about the suppliers can be found on this page. A doughnut chart shows the share of the suppliers in doing work at the site. (Figure 7.9 Work order detail page of CM/AI dashboard, A. Farokhi, 2022)

## Safety

Just like the work orders detail, on the safety page as well, there is a tree table which illustrates the distribution of HSSE reports per category. The users can immediately see what type of incidents happen more often within the sites. If incidents related to a specific asset is high, there is a possibility to antedate the replacement. In the same manner, if a contractor is having an alerting number of accidents, it might affect the decision to continue the work with them (Figure 7.10).


**Figure 7.7 The Main page of CM/AI Dashboard, designed by A. Farokhi, 2022**

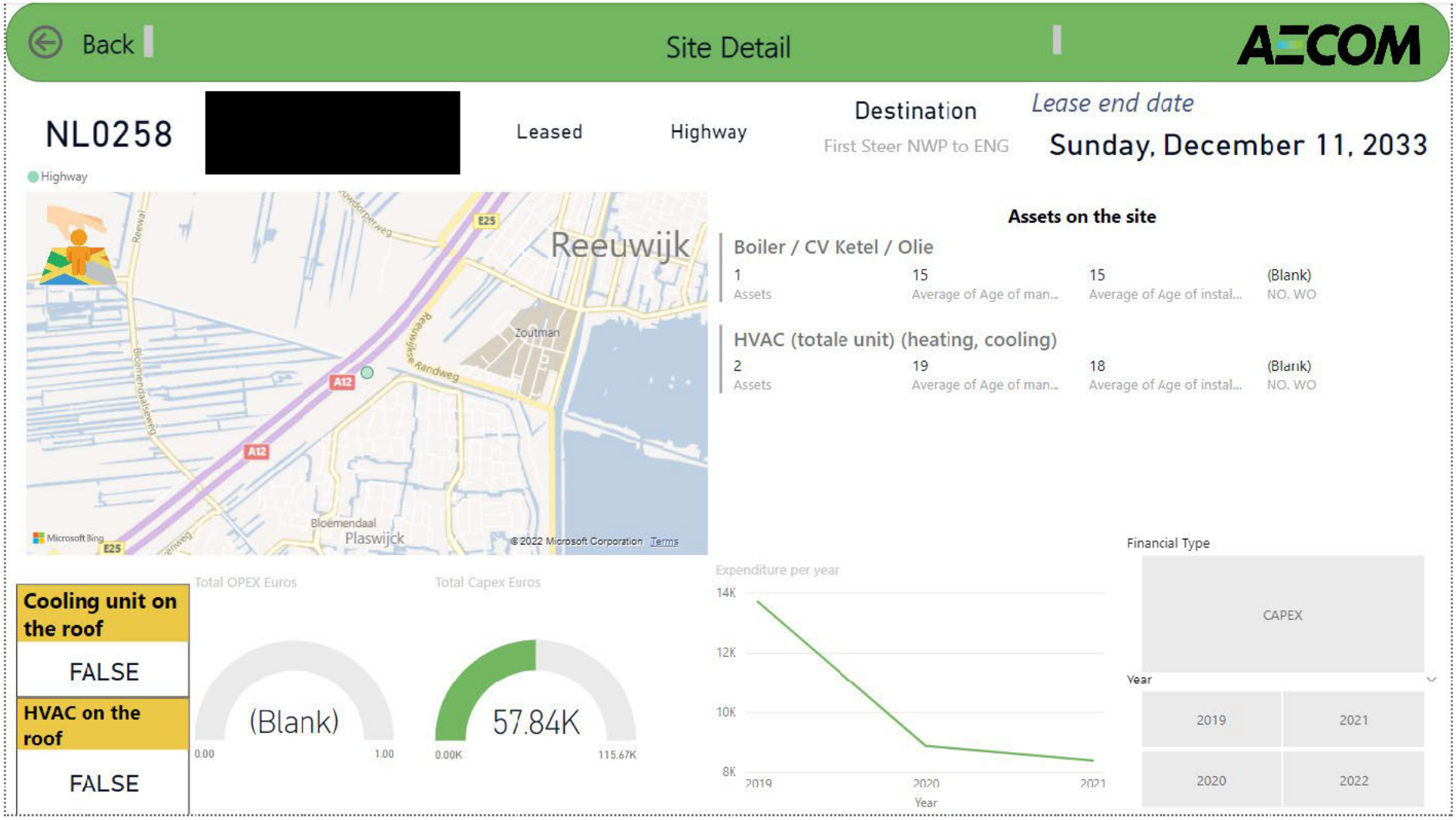


**Figure 7.8 Site detail page of CM/AI dashboard, A. Farokhi, 2022**

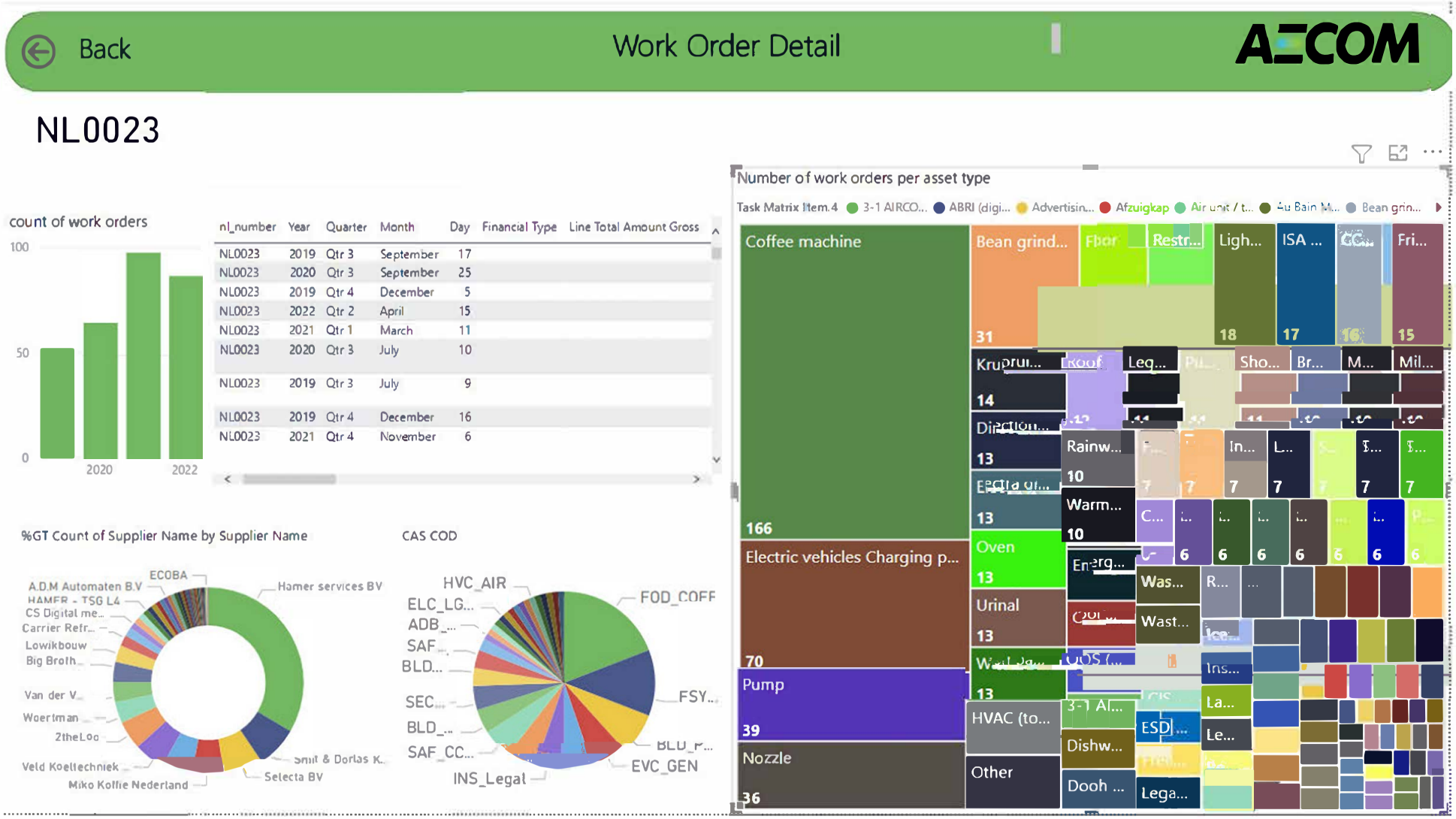


Figure 7.9 Work order detail page of CM/AI dashboard, A. Farokhi, 2022

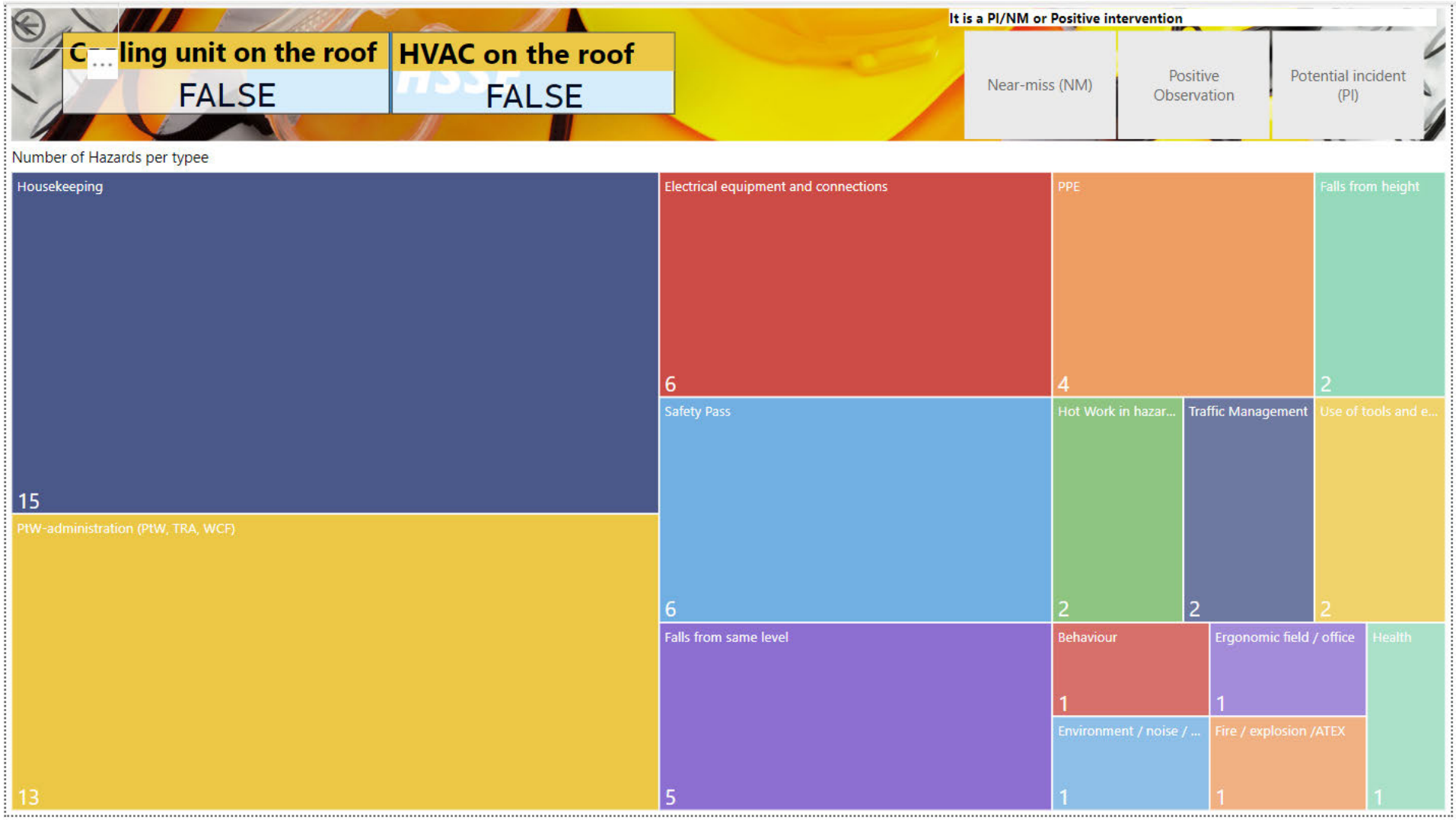


**Figure 7.10 Safety page of CM/AI dashboard, A. Farokhi, 2022**

# 8 Post Experiment Survey

This section explains the steps taken to set up the survey to evaluate the BI dashboard. After that, the survey results will be presented, answering sub-research question five.

## 8.1 Survey Setup

Each participant will complete the post-experiment evaluation survey after they feel like they have had enough interaction with the dashboard. It was recommended that they fill out the survey up to one week after the introduction of the dashboard, during which they could also ask any questions about how to work with the dashboard. The network specialists will analyse, based on their evaluation's findings, how the BI tool might impact and improve their decision-making process. The design of the questions will be guided by the insights gleaned from the interviews, which will seek to reveal instances of facilitation in the decision-making process.

Every survey is built around a questionnaire, and the design of the questionnaire determines the survey's performance. A questionnaire is merely a set of written or mimeographed questions filled out by or for a respondent to express his view, according to the definition provided. A questionnaire is used when there are limited resources because it is relatively inexpensive to design and administer, and time is a valuable resource that a questionnaire uses to the fullest extent. It is also used to corroborate other findings because questionnaires can be helpful confirmation tools when they are used in conjunction with other results and protect participant privacy. After all, participants will only respond in honesty if their identity is concealed and confidentiality is maintained. (Roopa & Rani, n.d.)

The poll will be conducted using Google forms and a 5-point Likert scale. A mix of close-ended questions and open questions will be used. The close-ended questions are based on a Linkert scale. A Likert scale is a closed, forced-choice scale used in surveys to offer a range of answers ranging from one extreme to the next. For instance, a scale may include five options, with "strongly agree" at one end and "strongly disagree" at the other, with three less extreme options in between (Likert, 2017). In the survey, statements will be made regarding the usefulness of the BI tool in the context of improving the decision-making performance indicators, enhancing the decision-making process, or multi-year plans. Using the scale, the specialists will score the improvement compared to their personal experiences of similar situations without the dashboard. Values below 3 indicate a decrease in productivity or a negative influence on work performance. Scores greater than three will indicate an improvement in the manner in which work is performed or the achievement of results. After the input from the interviews has been synthesized into indicators of decision-making performance (Chapter 6.1, page 44), the statements will relate to and reflect that input. The introduction of such technology at an EFM company will be evaluated by specialists, who will also be asked to motivate their answers by describing any potential barriers or strong points. The alignment between the themes, company goals, and review of the tool's functionality will be examined. The participants will next be asked to identify aspects of the BI portal's functionality that they found appealing and any obstacles they see to deploying such systems within an EFM firm. The survey can be found in Appendix B. In total, five participants participated in the survey. All five participants were project managers that worked in the CM/AI team, and they were not involved in the first round of the interviews. Also, before the survey was done, there was another meeting set up with the project leader to modify the dashboard and tailor make It before the actual evaluation. This was done to make sure that the participants would better score the concept of BI dashboards instead of focusing on the problems the current dashboard had.

## 8.2 Survey Results

Almost all respondents believed that utilizing this poll would bring time savings; however, while forty per cent strongly agreed and another forty per cent agreed it is likely to save time throughout the decision-making process, twenty per cent took a neutral stance. No one expected that BI dashboards would significantly lengthen the decision-making

process. According to one respondent: "By using this dashboard, there would be no need for so many meetings with the team to synchronize the information, hence saving a substantial amount of time and resources if the sessions were performed in person." Among other reasons, the BI dashboard would provide all project participants with unlimited access to all necessary information (unless otherwise required for privacy reasons). One of the situations in which there is a significant delay in decision making is when the decision makers want information that is held by another team member. Before making judgments, the decision maker must thus request the information and wait for a response. This is especially true for new team members who are unfamiliar with the dispersed bits of information that may be kept in numerous locations (such as MMS, SharePoint, online servers,..). As the BI dashboard gives a single point of access to information that can be used by all team members, it saves a substantial amount of time. The BI dashboard reduces the hierarchy of information access inside the business; without the dashboard, various individuals or teams, especially the data team, were required to deliver certain information. Now, any member may freely choose what they want to view, apply the filters they choose, and download any necessary information. One of the reasons that the respondents did not agree that the dashboard would unconditionally save time was that the effects of the dashboard were dependent on their source of the data, in this case being MMS, such as completeness and correctness of the data. Because the PMs are not still confident in the source data, they still need to cross-check the data. The process of cross-checking might hinder the goal of the dashboard, which was saving time. The answers can be seen in Figure 8.1 Post-evaluation survey question 1 results.

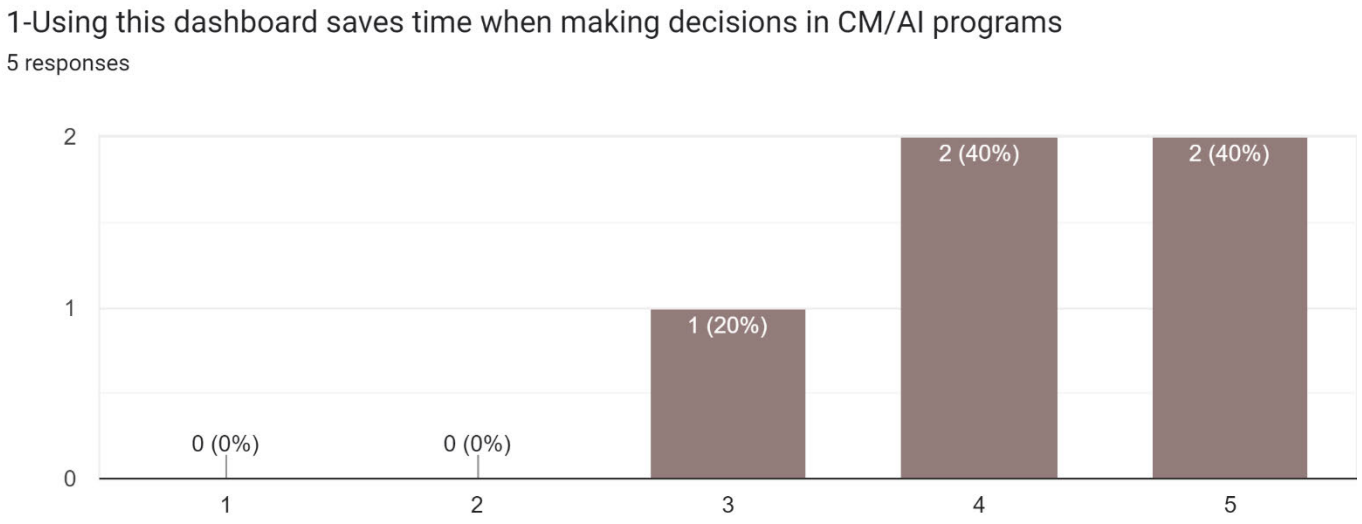


**Figure 8.1 Post-evaluation survey question 1 results**

When questioned about the effect of utilizing the BI dashboard to improve the safety performance of the EFM, on average, the respondents stated that this dashboard was "unlikely" to deliver any benefit. However, there are two groups of explanations for this. One relates particularly to the HSSE data included in the BI dashboard and its relevance to the CM/AI program, while the other relates more broadly to the use of dashboards for safety-related decision-making.

Regarding the first category, one respondent said, "I perceive no connection between the HSSE reports and the asset replacement program, or at least the PMs were not taught to do so." This statement emphasizes the necessity of adequate training for users and teaching them how to make data-driven choices in the first place and that it should not be assumed that everyone will utilize the data to make data-driven decisions just because it is available. In addition, it is crucial that the data selection is correct, meaning that the data shown on the dashboard is legitimate, relevant, and relatable and is, in fact, "input necessary for decision making". Another of the respondents stated:" This is dependent on the input. Current input is including NMPI's of the contractor, this has almost nothing to with asset on

site. Input should come from the site employees". This statement as well refers to the validity of the source of the data.

In the second category, a number of respondents emphasized the significance of integrating site visits with dashboard use when making safety-related choices. Some respondents stated that despite the fact that the better the dashboard becomes, the fewer site visits are necessary, this would never be totally eliminated. This requirement is much greater in the case of safety, and as a result, the present dashboard was deemed unlikely to deliver value to the organization. One of the respondents that strongly believed in the value of this dashboard in safety improvement stated the ability of the dashboard to give alerts on the rising number of incidents in a site which could help preventative measures to be taken. (Figure 8.2)

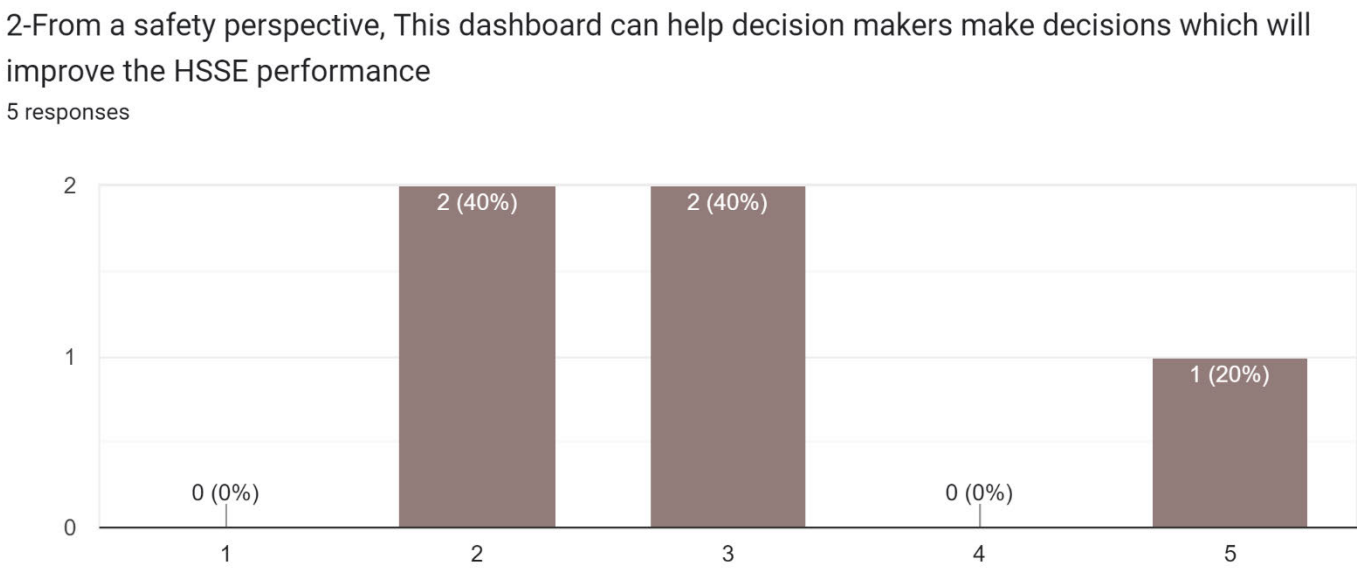


**Figure 8.2 Post evaluation survey results, question 2**

In the following section of the questionnaire, participants were asked about the financial benefit the dashboard may bring in terms of reducing TCO, enhancing transparency, and enhancing predictability. All respondents agreed that the dashboard would likely reduce the total cost of ownership. When you stop spending money on short-term fixes, the total cost of ownership will decrease. This clause underlines that data-driven decision-making utilizing BI in facility management facilitates better investment decisions on asset replacement plans, hence reducing the need for emergency repairs. Another answer stated, "[The dashboard] reduces the TCO by providing a quick and accurate summary of the previous years' financial costs and, as a result, an estimate for the upcoming years. Consider the period of each asset's lifetime. By utilizing BI dashboards to correctly identify CAPEX investment areas, OPEX will be reduced, resulting in a cheaper TCO".

On average, respondents were lukewarm regarding the dashboard's ability to increase transparency. One responder suggested that the capacity to generate reports directly from the dashboard for the customer and the decision-makers ability to support their decisions and recommendations to the client with dashboard data might enhance the transparency of EFM. Others, however, who differed in this regard asserted that they were already transparent to the client. The fact that the PMs did not use dashboards before this period does not imply that they did not regularly provide data and visualizations to the client, only that they did so in a different manner. Therefore, it can be argued that utilizing the dashboard will make it easier to be transparent but will not necessarily enhance transparency. (Figure 8.3)

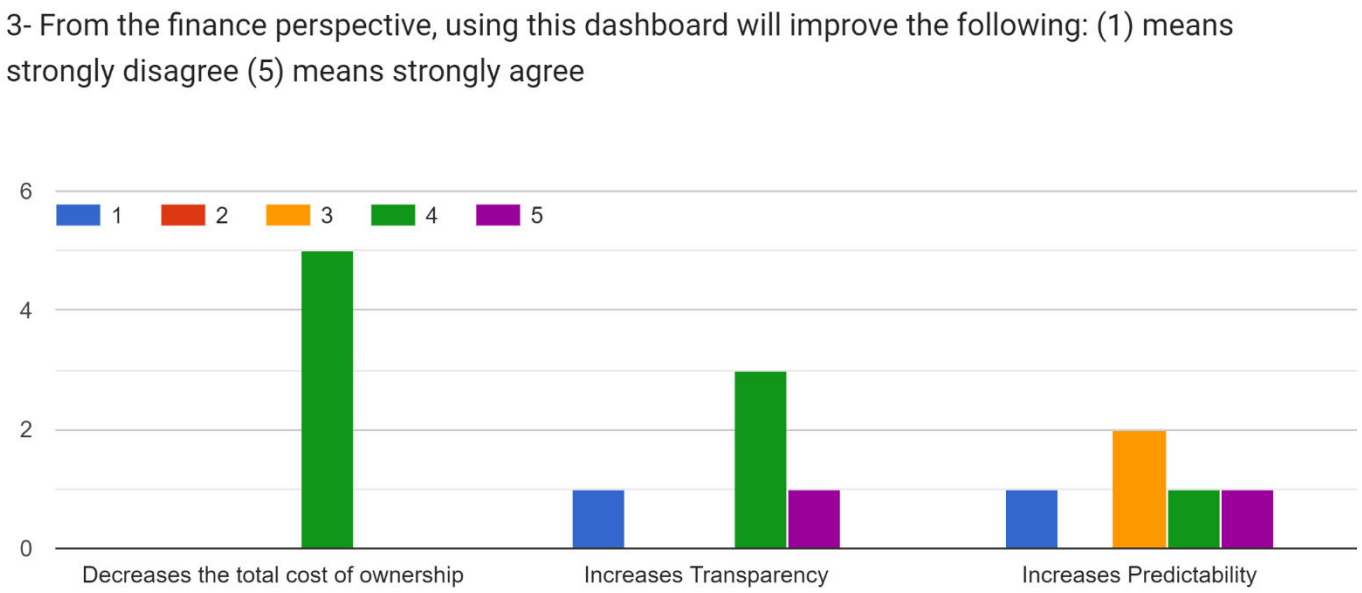


**Figure 8.3 Post evaluation survey results, question 3**

On average, the respondents believe that the dashboard is likely to increase predictability. Those who believed that the dashboard is very likely to increase predictability indicated the ability to see the trends and get a sense of the long-term changes in the expenditures and breakdowns. Others who thought that the dashboard is not very likely to increase predictability stated the need for high data accuracy in order to use the data to make predictions. Also, the dashboard did not provide specific illustrations that showed the trends and extrapolations, and it was left to the user to make the predictions based on their own needs.

In the area of quality, only fifty per cent of the respondents believed that the dashboard is likely to reduce asset downtime, while others found it not likely to do so. After analysing the responses, it was found that the reason that the dashboard does not perform well in decreasing the asset downtime in CM/AI decision-making is related to the fact that the asset downtime is affected by two sources: one is the response time of the site owner and the contractor, which indicates how long will an asset stay inoperative after it broke down. The other is the frequency of the assets breaking down. Naturally, the lesser the assets break down, the lower the downtime would be (with a minimum of zero hours when no assets fail). The pilot BI dashboard that was created is not an operational dashboard and is only used for strategic decision-making. Hence, it cannot help with the first source of downtime, meaning that after an asset has failed, using this dashboard would bring no value in making the fix happen earlier. However, this dashboard helps reduce the frequency of the repairs by better identification of the assets that are likely to break, for instance, based on their age or the increase in the trend of their work orders. (Figure 8.4)

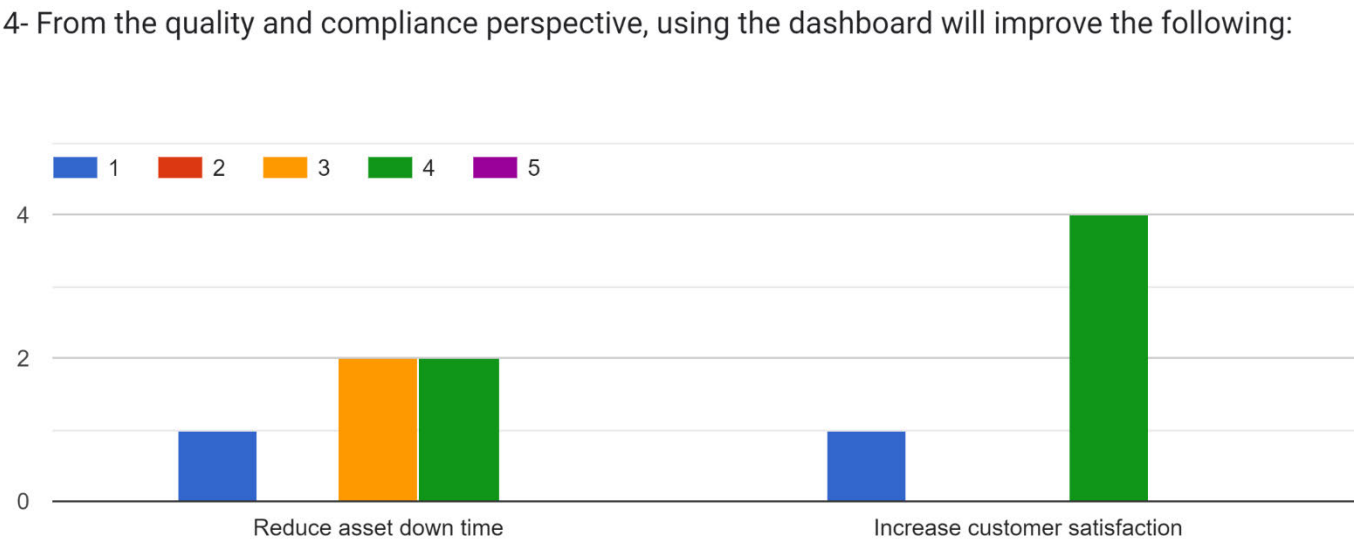


**Figure 8.4 Post evaluation survey results, question 4**

The second section of the survey aimed to determine if the expectations stated in the first section had been met. The dashboard was expected to be trustworthy as a prerequisite. Although the dashboard was merely a pilot, the objective was to employ accurate and up-to-date data so that when users compared it to data they had seen elsewhere or knew by memory, there would be no discrepancies. The results indicated that respondents rated the dashboard's credibility with an average score of 3.2 out of 5, indicating a moderate level of confidence in the data.

The dashboard also received an average score of 4.4 out of five for its capacity to visualize and integrate a significant amount of FMC data, as well as a score of 4 for its ability to bring several corporate divisions together for decision-making ( FMC, EPCM, Environmental team, third parties like the real estate managing company).

Respondents rated the dashboard's usability with an average score of 3.4. This grade was determined based on a thirty-minute meeting that served as an introduction to the dashboard and a training session. In terms of being future-proof, the dashboard received a score of four. In conclusion, respondents indicated that they intend to utilize the dashboard in the future. (Figure 8.5 Post evaluation survey results, questions 5 to 10).

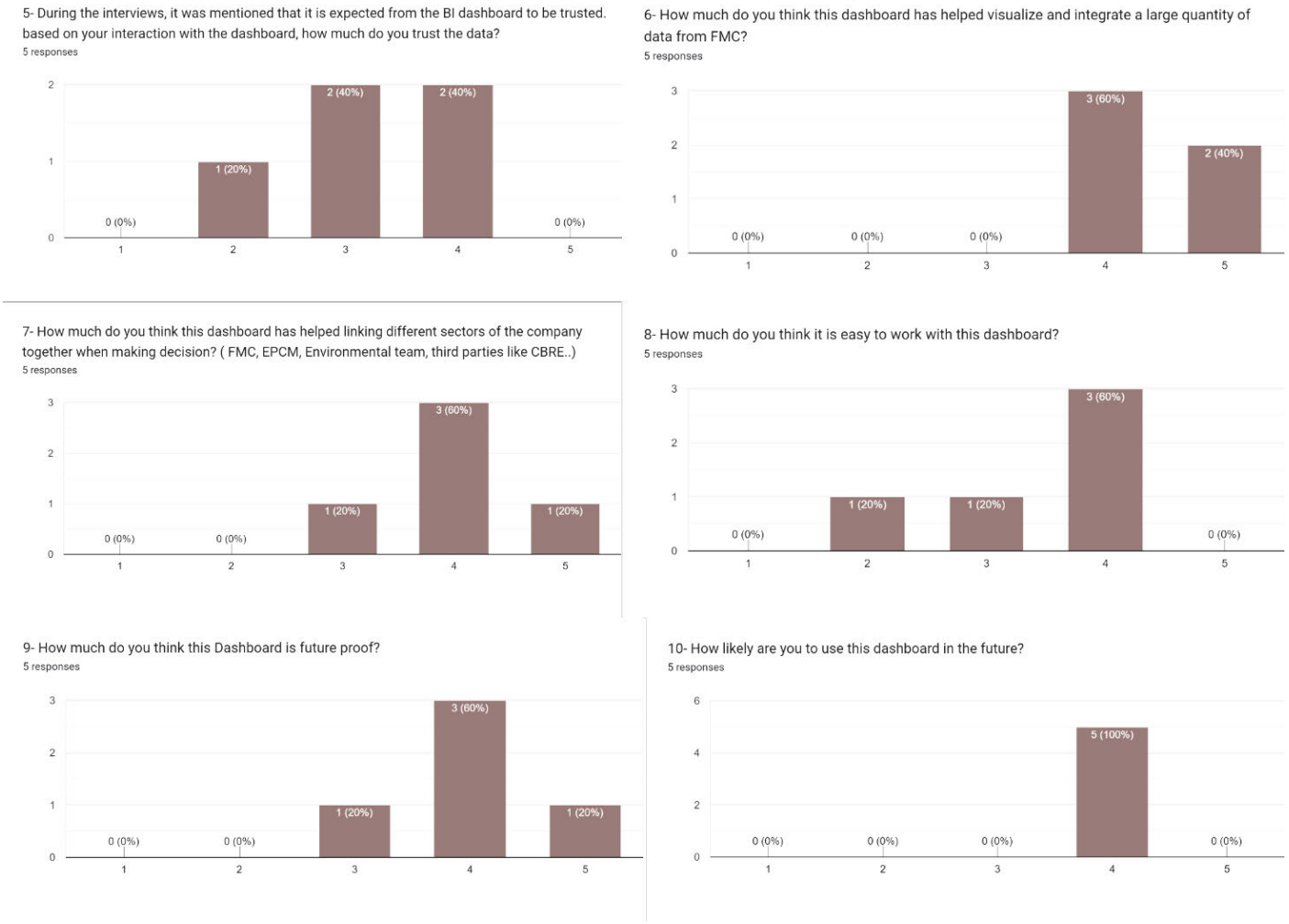


**Figure 8.5 Post evaluation survey results, questions 5 to 10**

# 9 Discussions and Conclusion

Facility management is a subset of management that focuses on the maintenance, development, and improvement of physical assets required to increase and progress the value of the business, as well as the creation and maintenance of a suitable physical workspace that provides optimal support for the organization's people and work (Drion et al., 2012). Enterprise facility management can be a complex task when it comes to geographically distributed assets and when a large quantity and variety of assets and stakeholders are involved. Facility management of filling stations in the Netherlands is not an exception. In 2021, the total number of gas stations in the Netherlands had reached 4,147, including uncrewed stations. Thus, parent enterprises, including oil and gas companies, have opted for third-party engineering consultants to perform the management of the facilities and non-core activities on their behalf (Potkany et al., 2015). AECOM Benelux is one of these companies being in charge of managing about 570 stations and more than 50,000 assets throughout the Netherlands.

The Facility managers soon realized the importance of data in their operational activities as well as strategic decision-making. Decision-making is a fundamental activity for managers. It is “the essence of the manager’s work” and “a fundamental component of organisational life.” (Robbins, 1991) and (Robbins, 2000). Management of filling stations is not an exception, and facility managers must make strategic decisions daily. In doing so, the managers are confronted with many challenges, including the overload of data and the biases in the manager’s conception, making them imperfectly rational (Molloy & Schwenk, 1995).

Due to the limitations of the cognitive abilities of the human mind in processing large data, decision-makers have soon realized the need for information systems to aid their decisions. Information Systems can be conceptualized in terms of three types of systems: Transactional Processing Systems (TPS), Management Information Systems (MIS), and Expert Systems. MIS has several subsets, such as Decision Support Systems and Executive Information Systems. With the development of technology, DSS has been using the latest information system technologies to deliver their goal (Nowduri, 2011).

AECOM as well has identified the importance of data-driven and metric-based decision-making. Every day there is a large amount of data being stored on the company's called maintenance management system. These data include information about the work orders that are being made from the sites, as well as information about the assets present in the network. Also, the contractual agreements and transactions between the client, AECOM, and the contractors are as well being stored in the same system. Due to the large scope of the work, the quantity of the data produced is abundant. Data-driven decision-making requires data to be first transformed into information, and then the information to be turned into knowledge and only after that the knowledge be used to make decisions. This process as well is very complicated. AECOM has been using mostly human power and Excel program as the main tool for their data analysis and as the DSS.

The procedure of turning data into a decision as the way it currently is comes with some problems. Among them is the dependence of the data analysis on an expert who knows the business by heart, the request-based nature of the analysis, which means for every information requested by the management, a separate analysis should be conducted by the expert who will repeat the process of extracting the data from MMS, polishing them and analysing them every time, and also the fact that it Is very time-consuming, in a way that some analysis could take months to be completed, which by then the data has already become obsolete and probably the results are not valid.

In this study, Business intelligence dashboards were introduced as the successor to the DSS to help deal with the issues the current decision-making process has within FM of filling stations. BI is a process and product. BI is a data-driven decision support system (DSS) that integrates data collection, storage, and administration with analysis to offer input to the decision-making process (Jourdan et al., 2008). A dashboard is a single-screen user interface that consists of a static structure which makes information available at the right time using indicators. A dashboard provides an interface

that aids managers and executives in getting data immediately from various departments in a similar format and makes it more accessible. Dashboard design also plays an important role in the decision-making process. It should be easy to use and should consist of all the capabilities such as customization, audience targeting, colour display, etc., to facilitate the decision-making process. Depending on the specific business application where a dashboard is used, the design and functionalities may vary (Golfarelli, Rizzi, Formula, et al., 2004).

The goal of this study was to determine whether applying the BI dashboard in decision-making would bring the expected values. To achieve this goal, several research sub-questions were designed. First, a study was conducted on the notion of decision-making within the EFM of filling stations and then, based on that, a pilot dashboard was designed to evaluate the findings.

## 9.1 Answer To The Research Sub-Questions

Based on the findings of this study, the research questions are answered as follows:

1- What is the state of the literature on the topic of data-driven decision-making using BI with a focus on EFM?

There have been numerous studies on the subject of using IS in decision-making. Also, several studies have specifically focused on the applications of BI in decision-making. Among them can be mentioned the works of (Barycki, 2020; Geng & Wang, 2022; Giordano et al., 2022; Ma et al., 2020b; Mohammadi et al., 2021; Tanphet & Wanchai, 2018; Wieder & Ossimitz, 2015).

According to (Lönnqvist & Pirttimäki, 2006), BI Benefits for companies include reduced cost, increased revenue, enhanced business performance and better decision-making. However, many companies struggle to manage their BI solution because it is complex and requires ongoing management (Davenport, 2012). Several instances of application BI tools in decision-making in FM have also been provided. They all showcased improvements in the decision-making process.

2- What are the top strategic decisions in EFM regarding filling stations at the management level, and what Is the decision-making procedure within AECOM?

The interview results revealed that the ultimate objective of decisions is business continuity and growth. Business continuity and growth can be represented by three operation categories, often known as operation pillars. The three operation pillars are Finance, Quality, and Safety. Any improvement in these pillars would contribute to the overall objective. The decisions can be classified according to whatever pillar they aim to enhance.

One further classification of judgments is based on their intended audience. The decisions may concentrate on two areas: A. Assets and B. Individuals. Asset-related decisions include the choice of asset type, brand, model, and replacement date or location. People-related decisions include contractual agreements such as the selection of suppliers, the form of reimbursement, and decisions on training programs. By combining pillars and target groups, a total of six distinct choice kinds are possible. Nevertheless, a single decision can belong to multiple decision groups.

3- What input is required in making the identified decisions in EFM of filling stations?

The input required for decision-making varies per decision group. In general, the decisions regarding assets require information about the asset's physical identity, such as age, model, manufacturer, energy consumption and repair history.

Decisions regarding people, in general, require information about the ongoing contracts and their clauses, the legal status, the financial data, the safety performance and the KPIs of the contractors. The process of turning data into a decision is a cycle and not a straight line. Meaning that it is very difficult to identify all the required data and then

make decisions based on it. In reality, sometimes, first, the decision that needs to be taken is identified, and then the input required for it is collected.

4- What indicators can be used to evaluate A. These strategic decisions and B. The decision-making process in EFM of filling stations?

The interviews revealed that the performance of decision-making could be evaluated using two key indicators: A. Time and B. Results. The decision-making time in this context refers to the time required for the decision maker to collect sufficient data and analyze it in order to reach a conclusion. This does not refer to the amount of time required for the decision to be accepted by the authorities or implemented. Changes in the previously listed operational pillars can be used to quantify the outcomes. Of two comparable options, the one that results in a greater increase in finances, quality, and safety and is made in less time is deemed the superior choice. A comparison can be made using a weighted criterion comparison in which each indicator is assigned a weight, and a scale is specified for each category.

5- What are the expectations of BI dashboards from the facility managers of filling stations?

The interviewees mentioned that they expect the dashboard to be trustworthy, simple, workable, future-proof, overarching (linking different sectors of the company together to avoid double work) and also visual so that it can cover a large amount of data with simple illustrations.

6- How has decision-making within EFM of filling stations improved based on the identified indicators after using the pilot designed for the purpose BI dashboard?

The findings indicate that utilizing the dashboard can save time. It is accomplished by avoiding the requirement for many meetings to synchronize information from various team members during multi-year planning. BI dashboards also simplify information access by providing a single point of access to the information for all users. Additionally, there is no need to continually seek data from the data team or other departments. It is suggested that the dashboard can only save time if it can be relied upon. Otherwise, users must cross-check the data to confirm its veracity. The procedure of cross-checking can negate the time-saving benefit.

The post-experiment survey revealed that using this dashboard is only beneficial if users are trained to make data-driven decisions based on the information presented. This is referred to as information relevance, and it is important that consumers understand how the information presented to them will impact their decisions. Also, the data source must be reliable.

In terms of safety, the results suggested that dashboards could not completely replace site visits. Consequently, they may not provide the anticipated value. One advantage of using the dashboard is that it can inform customers by displaying safety benchmarks, allowing them to identify dangerous sites and make additional judgments.

All of the project managers who evaluated the dashboard agreed it might aid in reducing TCO. Using BI to make data-driven decisions in facility management improves investment decisions on asset replacement plans, hence lowering the need for emergency repairs. The overall cost of ownership will reduce when you cease spending money on short-term solutions. By appropriately identifying CAPEX investment areas using BI dashboards, OPEX will be decreased, resulting in a lower TCO.

The use of BI dashboards does not inherently raise the company's transparency, as it was already high, but they enable it by making it easier for clients to generate reports and by offering a single source of truth. As the dashboard did not include any built-in prediction tools or extrapolations, it was the user's job to generate predictions by evaluating the trends. Therefore, not all PMs could completely benefit from it.

Asset downtime is influenced by the site owner's and contractor's reaction times. Also included is the asset breakdown. Fewer breakdowns translate into less downtime (with a minimum of zero hours when no assets fail). The trial BI dashboard is not used to make operational decisions. It cannot assist with the root cause of downtime; hence, applying it after an asset fails will not accelerate the repair. This dashboard assists in reducing the frequency of repairs by identifying assets that are prone to fail according to their age or work order pattern. In general, the survey results indicated that the dashboard matched user expectations, and respondents indicated that they are likely to utilize the dashboard in the future.

## 9.2 Conclusion

In conclusion, this study demonstrates that the installation of BI dashboards might be a realistic solution for EFMs to promote business continuity and growth by lowering decision-making time and enhancing decision outcomes in the areas of finance, quality, and safety. To successfully install BI dashboards, however, the necessary BI implementation processes must be followed. Ranjan (2008) presents a checklist of the necessary procedures for BI implementation. The findings indicate that the availability of a dashboard without proper training on how to make data-driven decisions with the data supplied is rarely beneficial. In addition, the validity of the dashboard is proportional to the validity of the data it receives. For a dashboard to be genuine, the source it draws from must also be valid. In addition, it should be remembered that business intelligence is a cycle, and for the cycle to function well, there must be a constant identification of decisions and collecting and processing of data based on those decisions.

## 9.3 Recommendations

Companies have been aware of the significance of data management and data-driven decision-making for quite some time. Since 2009, firms have spent the most on BI relative to their total IT budgets (Kappelman et al., 2017). BI implementation needs multiple steps, as shown in Figure 4.7 of the BI implementation guide (Ranjan, 2008). From the perspective of the company, AECOM already possesses all the requirements, including a corporate mission and vision statement, justifications for adopting a centralized, managed approach to BI, and now, with the findings of this study, Justification of BI acquisitions using application-specific use, end-user surveys and requests, and IT decisions.

In addition, the findings of this study have satisfied the majority of user and corporate standards, including Details of a comprehensive end-user segmentation and evaluation methodology, Details of a standard for BI tools: education and support, Details of end-user requirements for the current tools, and Details of corporate infrastructure (user group, newsletter, etc.) for BI and their processes. However, AECOM must still develop a defined and authorized BI strategy for external and internal users, as well as time and cost breakdowns for BI tasks.

The specifics of databases, tools, and vendors are one of the most expensive needs for BI implementation. Fortunately, AECOM has already made significant progress by establishing the MMS. Nevertheless, as shown by the findings of this study, it is crucial that AECOM confirm the accuracy and reliability of the current data and implement procedures to collect missing data. In addition, it is suggested that AECOM implement routine quality assurance checks.

The training of project managers and program managers to make data-driven decisions is another area where AECOM can aim to make changes. In order for the decision-making process to create a complete BI cycle, they should be able to use the present data to make better decisions and, in the next step, provide feedback to the data team regarding the data that is required for decision-making.

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