Tampereen yliopisto

Kai Kolehmainen

DEFINING ASSET MANAGEMENT PROCESSES

Master thesis

ABSTRACT

The purpose of this thesis was to evaluate the practices of asset management in a Finnish railway company, VR Group based on available literature and the ISO 55001 standard. A qualitative research design was employed to answer the three research questions regarding asset management interfaces, maintenance, and processes of establishing the fundamentals. The results reveal the importance of the operation interface during planning and control of rail infrastructure. ISO 55001 emphasize on the need for establishing all functions undertaken by a rail company to successfully integrate asset management controls and plans.

According to ISO 55001, policies ensure good organizational practice by providing statement of intent by the top management group. For the railway company to sustain sustainable policies, communication between the leadership and stakeholders is important. The research found out that awareness of the policy, especially among internal stakeholders played a vital role in enhancing the efficiency of asset management practices. ISO 55001 is concerned with the requirements for constructing a reliable and productive asset management system. Therefore, this standard outlines a model for identifying appropriate policies, goals, and governance needed for accomplishing strategic objectives of a company.

Various design and maintenance activities represent the major operations performed by railway organizations. Assessment of asset condition and necessitated levels of service from rail networks are discussed under the performance metrics. Forecasting and performance modeling coupled with funding assessment comprise the needs analysis section. On the other hand, program optimization and alternative assessment are identified under the program analysis section. Primarily, business operations consist of information, technological capabilities, and capabilities within a railway company. These operations are necessary for the rail company to appropriately describe the various inputs and outputs associated with asset components and demonstrate the key stakeholders of these inputs and outputs. Operation's key output includes accountabilities and roles among members. Regardless of possible research biases and limitations, the study outcomes comprehensively answer the three research questions.

The research examines various organizational responsibilities and functions associated with the leadership interface. To facilitate effective management of railway infrastructure, leaders must understand their specific roles in ensuring compliance with the standard. Further, the findings describe the asset management phenomenon in a holistic approach using Finnish railway company as the main context of the study. Conclusively, ISO 55001 is an effective and reliable standard for efficient management of railway infrastructure and tracks.

Keywords: Qualitative research, asset management, rail infrastructure management, ISO 55000,

ALKUSANAT

What a journey!

Omat suunnitelmat yliopisto-opiskelusta, uusista kavereista ja opettajista muuttuivat heti opintojen alussa, kun Covid-19 pandemia alkoi ja pysäytti lähes kaikki toiminnot, mukaan lukien lähiopetuksen yliopistossa. Niinpä olen suorittanut kaikki opinnot kokonaan etänä, mistä suuri kiitos Tampereen yliopistolle, että se on mahdollistanut sen.

Minun opinnäytetyötäni valvoi professorit Seppänen ja Vaismaa, kiitokset heille rakentavasta palautteesta, keskustelusta ja etenkin kärsivällisyydestä. Kiitokset myös työnantajalleni VR Fleetcare Oy:lle työn- ja opintojen yhteensovittamisesta, joustavuudesta ja sparraamisesta.

Suurimmat kiitokset kuitenkin kuuluvat vaimolleni Lauralle, perheelle sekä ystäville. Ilman teidän tukeanne ja kannustusta tämä ei olisi ikinä ollut mahdollista. Nyt on minun vuoroni olla läsnä, harrastaa, ottaa hetki happea ja miettiä tulevaisuuden suunnitelmia. Kiitos ja näkemiin.

Turussa, 31.10.2021

Kai Kolehmainen

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1. INTRODUCTION

1.1 Thesis background

Maintaining railways relies on the capacity to optimize the integration of the asset base. The rail industry necessitates the implementation of a periodic asset improvement practice that necessitates the maintenance workforce to consistently enhance their comprehension of facility performance. This thesis focuses on asset management of the VR Group, a government-owned Finish railway company. The company mainly operates Finland's passenger rail daily services and processes. Since its inception in 1995, VR Group remains one of the major rail operators in the region, accounting at least 39 percent of the entire public transport (VR Group, 2021). Further, the company performs 250 long-distance travels each day, necessitating consistent development for efficient service delivery (VR Group, 2021). The busiest Finnish rail route that links Turku and Helsinki benefits from continued asset management practices, aimed towards enhancing current rail projects in the area. These management practices led to the integration of the Pendolino trains, which are effective and sufficient high-speed and electric passenger trains (VR Group, 2021).

Asset management is primarily aimed towards accomplishing a precise balance of performance and cost of an asset with respect to company goals and expectations of the stakeholders. The International Standards Organization (ISO) introduced the 55000-management spectrum in 2014 (UIC, 2016). This thesis based on ISO 55001 standard, which concentrates on asset management systems and requirements in the Finnish rail industry. The standard also provides the way forward for enhancing performance across physical assets utilized by an organization. In addition, it promotes a structured process of optimizing investment decisions for improving stakeholder value at the least expense and justifies the risks associated with asset activities. Finally, ISO 55001 promotes transparent governance of physical assets to mitigate possible inconsistencies in terms of planning, decision-making, and strategic management (UIC, 2016). This standard is fundamental for VR Group since they reflect a worldwide consensus regarding the defining of asset management and how it can be applied to enhance asset value generated by the company. ISO 55001 describes the components of an effective asset management

system, capable of increasing value at the lowest cost possible. The standard is designed for rail organizations with significant physical assets to ensure value creation in the long term (UIC, 2016).

The main purpose of efficient asset management practices is to facilitate appropriate decision-making processes to assist organization maximize value through their physical resources (Piryonesi & El-Diraby, 2020). Proper management of rail assets promotes organizational objectives of output performance by transforming company targets into better strategies, plans, and decisions. Further, strategic benefits of appropriate asset management of rails include enhanced understanding and management of risk, enhanced governance, increasing return on investment, optimized operations, and incremental reliability and performance (UIC, 2016). Realized advantages from the ISO 55001 guidelines ensure safe and regulated railways in Finland that maintains future wellbeing of the sector.

Asset management is highly concerned with delivering stakeholder value and promoting sustainable infrastructure rail networks across Finland at a minimal cost. According to (UIC, 2016; Piryonesi & El-Diraby, 2020; Litherland et al., 2021) asset management entails three primary features regarding large scale physical assets and infrastructure. First, it concentrates on facilitating sustainable performance and outputs to stakeholders and clients through continued maintenance, updates, and improvements on key infrastructure networks (Piryonesi & El-Diraby, 2020). Second, asset management involves an incorporating mechanism that links company activities and disciplines towards improved decision-making processes in the company (UIC, 2016). Third, it promotes evidence-based and informed decisions based on information regarding asset degradation and the need for maintenance procedures (Litherland et al., 2021).

Optimal management of rail facilities and networks is significant in promoting strategic implementation of frameworks. These features consider diminished life cost and volume of work required to create asset value based on stakeholder expectations. Railway companies that integrate this standard during asset management practices accomplish good practice, which acts as the foundation for continued asset improvement and realization of stakeholder expectations (Litherland et al., 2021). ISO 55001 conveniently combines all operations and activities associated with railway infrastructure in a single system, which highlights strategies for maintenance, upgrade, and disposal upon crucial assessment.

1.2 Research questions

This thesis is employed to answer the three established research questions regarding asset management interfaces, maintenance, and processes of establishing the fundamentals. The first research question is:

RQ1: What is the process for determining the fundamentals of asset management for an organization?

This question is essential for the railway company since it is concerned with the alignment of organizational objectives with stakeholder expectations and legal necessities. The primary goal of asset management for rail infrastructure is to accomplish expected areas of service with minimal cost for current and prospective stakeholders. As such, the process for establishing asset management fundamentals is integral for VR Group's infrastructure planning and delivery activities. Considered aspects of asset management for rail infrastructure in this question are:

- The identified level of performance

- Risk evaluation and control

- Long-term budgeting of infrastructure investments (Piryonesi & El-Diraby, 2020; Westhuizen & Gräbe, 2013).

Therefore, the process for identifying asset management fundamentals for VR Group follows risk-based model for attaining the balance between performance and cost for infrastructure planning and operations.

Asset management fundamentals are founded on ISO 55000 standard, which outlines the principles and elements. According to the document, asset management comprises the following fundamentals:

- Asset value for the company

- Association between organizational goals and operations

- Leadership and organizational culture (UIC, 2016).

Discussed processes for determining the fundamentals of asset management for the rail company are the lifecycle process (rail service life); basic rail operations; progressive process to infrastructure management; and asset register. First, when determining asset management fundamentals, rail companies must consider infrastructure's service life or the lifecycle and the associated expenditures (Westhuizen & Gräbe, 2013). As illustrated in Figure 1. below, maintenance and operation expenses are relatively higher compared to initial expenses. These costs must be considered to facilitate an effective and reliable

solution. The lifecycle process promotes financial and strategic planning, rail service provision, and maintenance to ensure efficient activities. Various sub-questions are selected in the development of the lifecycle process for establishing asset management fundamentals:

- What is the worth of current rail assets?

- What is the desired service level?

- What are the financial plans for the infrastructure?

- How is financial reliability accomplished for the desired service level?

Information collected from the answers assist in identifying asset management fundamentals and ensuring cost-effective utilization. For instance, VR Group should establish a balance between initiating new capital assets and maintaining the sustainability of exiting assets. This process enables companies to comprehend the expected impact of financial decisions concerning infrastructure operations. Thus, the lifecycle process is crucial for identifying asset management fundamentals towards ensuring cost-effective rail solutions for achieving desired service levels (Westhuizen & Gräbe, 2013).
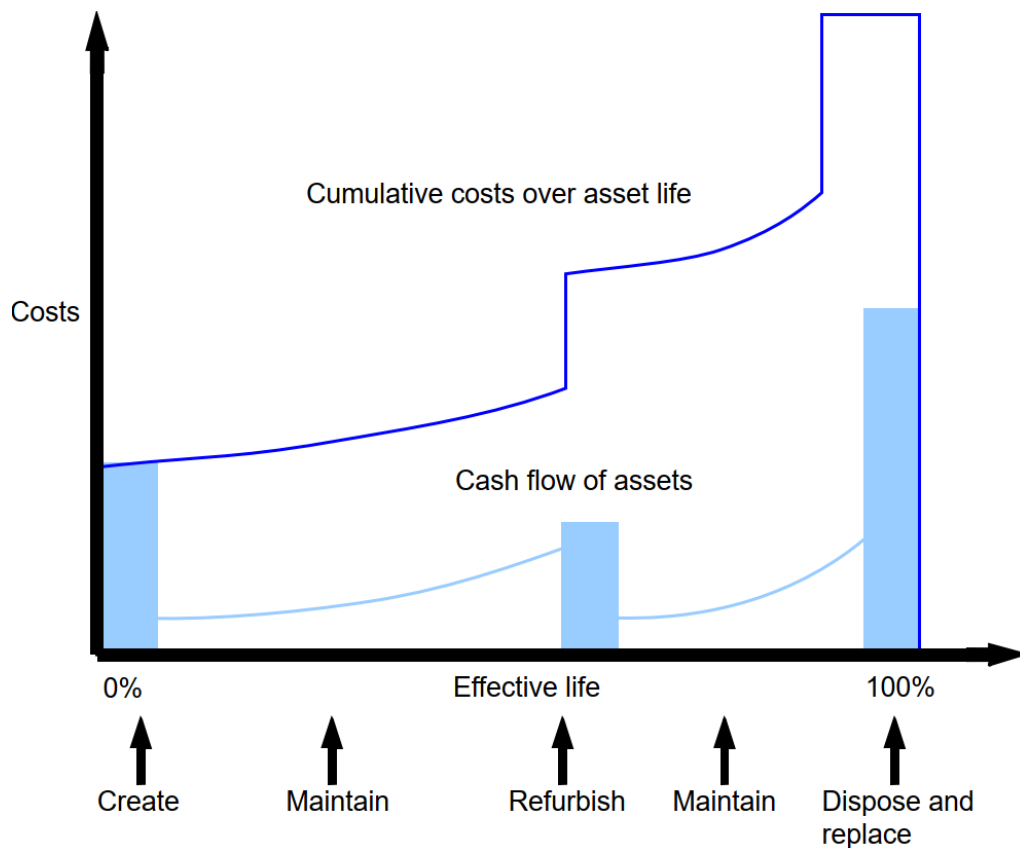
Figure1. Lifecycle process of rail asset management (Adopted from Westhuizen & Gräbe, 2013)

The process of establishing basic infrastructure operations is crucial for evaluating asset management fundamentals. This process encompasses the expression of financial and physical assets; definition of the required level of operation; illustration of asset life plan for a 10-year period; and optimization of the decision-making activity (Westhuizen & Gräbe, 2013). Figure 2. below indicate the basic infrastructure operations that are founded on data collection on existing rail assets.
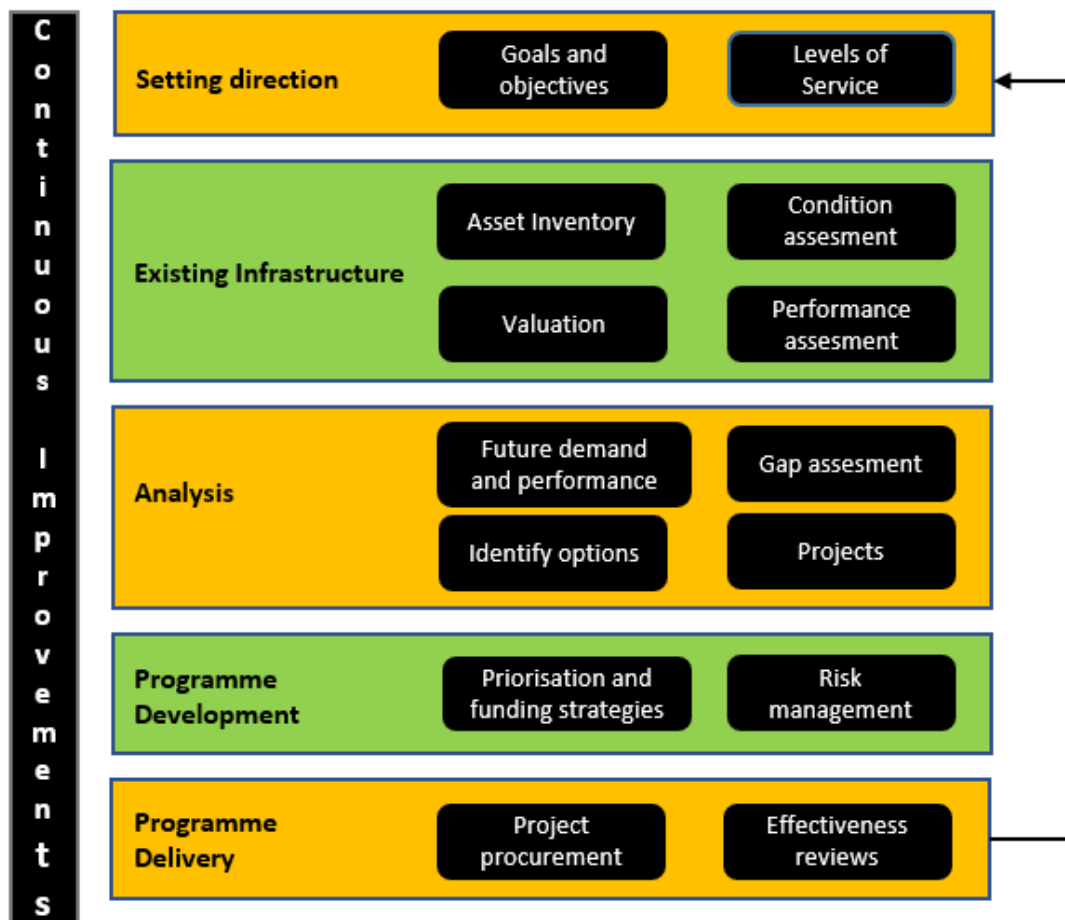
Figure 2. Major practices for the entire asset management process (Adapted from Westhuizen & Gräbe, 2013).

Consequently, the progressive process to infrastructure management based on ISO 55001 is necessary for attaining reliable infrastructure operations. Progressive stages are considered for determining the asset management fundamentals for a railway company. The initial improvement stage for asset management involves the asset register utilized to determine and implement a sustainable strategy. Throughout the process, an organization should consider the desired service levels, asset condition evaluations, and the long-term investment plan. As a result, the key processes for determining asset management can be categorized into the following sets of components:

- Asset register

- Policies and expected service levels

- Condition evaluation

- Maintenance and performance monitoring

- Infrastructure needs

- Delivery outcomes (Piryonesi & El-Diraby, 2020).

These processes are interrelated and focus on promoting asset management fundamentals towards improved service provision from railway companies.

RQ2: How is the asset management maintenance process ensured?

Maintenance refers to periodic asset servicing and care of related components. The aim of maintenance management of physical assets is to facilitate successful operations and functionality over a life cycle. These processes can detect potential failure or defects of rail assets and integrating standards for enhancing the effectiveness of activities (Abuzayan et al., 2014). The maintenance process in ensured through various quality assurance approaches: check reviews, quality established for providers' agreements, framework reports to recognize holes and errors. A powerful system should uphold an association with applicable asset management cycles and exercises, for example, resource stock, arranging, maintenance and upkeep needs, speculation displaying, stockpiling and extra parts, space booking, the executives of resources condition observing, routine support, and significant fixes (Piryonesi & El-Diraby, 2020. Overall, it ought to permit the capacity and the executives of all resources related data in an incorporated manner. The subject of Data Quality is another illustration of a space of business which has an ISO standard relevant to it: ISO 8000 Data Quality was distributed in 2011 (Yahaya et al., 2018). It could be especially supposed to be valid in the business that an easy to use and compelling system ought to be gotten to and imagined spatially to have a cross resource view and report resource execution. For instance, the data/information with respect to mishaps that happen in a particular segment, the general climate and geography, the street calculation itself, track surface boundaries and waste conditions on that segment, when seen graphically make multifaceted examination simpler and more instinctive (UIC, 2016). Caring of assets maintain the reliability and capability necessitated by stakeholders. For railway asset networks to deliver efficient services, maintenance management is highly recommended. Various advantages associated with asset-optimization include: Reduction of failures; Increased effectiveness; Maximizing quality; Enhancing utilization;

Minimizing incidents. ISO 55001 applies a systematic approach that facilitates a continuous enhancement and value creation through precise asset-based performance, risk, and expenses. The other two standards (ISO 55000 and 55002) supplement ISO 55001 by highlighting the principles and guidelines for its integration (UIC, 2016). However, this standard cannot be employed to demonstrate financial and technical requirements for asset management since it concentrates on the aspects for a management system. It is fundamental for railway companies to implement the ISO 55001 due to the following reasons: Assessment and better comprehension of the company's context and the expectations of the stakeholders (Zuashkiani et al., 2011). The standards assist asset-based organizations to facilitate reliable assistance for sustainable asset management, such as communication, awareness development, and precise allocation of resources and coordination across the organizational structure, internal stakeholders, technological systems, and employees with respect to operating needs, performance monitoring, and measurement of the management system based on the company's asset portfolio. Proper understanding of potential risks, as well as continued management is a global requirement in the ISO 55001 standard. Risk management is essential during the description and integration of the asset management system. When planning asset activity, railway companies are encouraged to identify possible methods for managing risks during operations. ISO 55001 clearly reflects on the risk management guidelines outlined under ISO 31000 (Glasson, 2017). These guidelines are fundamental for railway companies since they define the impacts of uncertainty on company goals and objectives. These uncertainties encompass both opportunities and threats in the rail industry. Like the ISO 55001 standard for sustainable asset management, this document illustrates appropriate models for effective risk management practices (Glasson, 2017). As a result, ISO 31000 is highly recommended since it does not merely guide asset managers on how to manage risks, rather it allows them to implement the most appropriate framework depending on the industry and stakeholder expectations (Glasson, 2017).

Railway companies should facilitate strong strategic plans for designing, constructing, and maintaining assets against possible uncertainties, issues, and dangers that can occur during operations (Halfawy, 2008). In this view, the choice of a risk management framework should depend on established threats and opportunities in the rail industry and their impact on organizational objectives and goals. Through this, a company can reliably come up and implement reliable response measures for ensuring continued activities in the event of uncertainties. The recommended risk management framework for railway companies is the ALARP technique which represents "as low as reasonably practicable" (Halfawy, 2008; Tafazzoli, 2017). Based on this model, companies can weigh a

risk against the expected outcomes and available resources for managing it. Appropriate implementation of risk management techniques assists rail companies to closely monitor and improve crucial operational areas, including the financial landscape, environmental effects, infrastructure performance, and other critical risks towards realization of stakeholder expectations.

RQ3: What are the main internal and external interfaces of the asset management system?

The leadership interface is crucial for effective rail asset management in Finland. Leadership is associated with the top organizational levels, committed to achieving relevant organizational goals and objectives. Top management in the VR Group railway company is comprised of the chief executive officer, the board, and authorization body of the management system (VR Group, 2021).

The various departments of the VR Group are headed by the director of maintenance and operations, director of engineering, and director of asset management (VR Group, 2021). Authority firmly affects how the hierarchical culture is assembled, its sort and on the off chance that it upholds the conveyance of good asset management. Albeit the nature of a company's administration, experience and ability on asset management are not viewpoints simple to see from answers to a survey, it is a key factor, for the execution of a system as well as for its proceeded with effective activity.

The underlying expenses of receiving another framework are fundamentally because of the way that, in numerous companies, there is an absence of asset management culture and involvement with' the top administration level. As an outcome, asset management on projects is for the most part did not draw closer in an incorporated manner, yet rather centers just on a couple of parts of the asset management cycle (Litherland et al., 2021). In rundown, the examination demonstrates that utilization of the condition investigation models will build the adequacy of the upkeep the executive's interaction.

By executing a condition-based and condition performance-based upkeep procedure, the rail companies can accomplish an absolute support cost decrease of roughly 17 percent and an increment in resource accessibility of around 30 percent (Chen & Bai, 2019). Previous studies show that when railway organizations provide conditional and maintenance-based support, they can set aside a significant part of the maintenance costs and extend the limit at about the same rate.

Recommended practices within this interface include ownership clearance, continued enhancement of the asset management, and directing corporate vision towards the realization of organizational goals (Hanski et al., 2016). In this view, the initial sub-section

of the leadership interface entails commitment from the top management to facilitate organizational goals. The second category within the leadership interface is the asset management policy.

2. LITERATURE REVIEW

This section performs a systematic review regarding the aspects of asset management practices and processes. The primary purpose of the literature review is to examine current and available studies concerning asset management, particularly in the rail industry. Asset management refers to a well-defined process of sustaining and enhancing operating company assets through integration of engineering principles and business rationale to achieve public expectations. This area is applicable across diverse fields of finance, engineering, and information management for assisting corporations to manage their resources cost-effectively and sustainably. Various tools and standards are integrated by major industries to facilitate sound and organized decision-making approaches for maximizing asset usability and reliability. For instance, proper management allows efficient allocation of finances based on the return value of the assets.

2.1 Asset Management Concepts

Policy objectives are essential for comprehensive asset management practices. According to various studies (Abuzayan et al., 2014; Chen & Bai, 2019; Prescott & Andrews, 2013), goals and objectives are essential for constructing the desired asset management system. As illustrated by Abuzayan et al. (2014), programming and planning are necessary concepts for the management of several kinds of physical infrastructure components illustrated in Figure 3. below. Periodic performance assessment of an asset management system is fundamental for accomplishing policy goals and objectives. Furthermore, a structured system should establish crucial information regarding the implication of allocating resources across different facilities, such as rail, aviation, bridges, and ports.
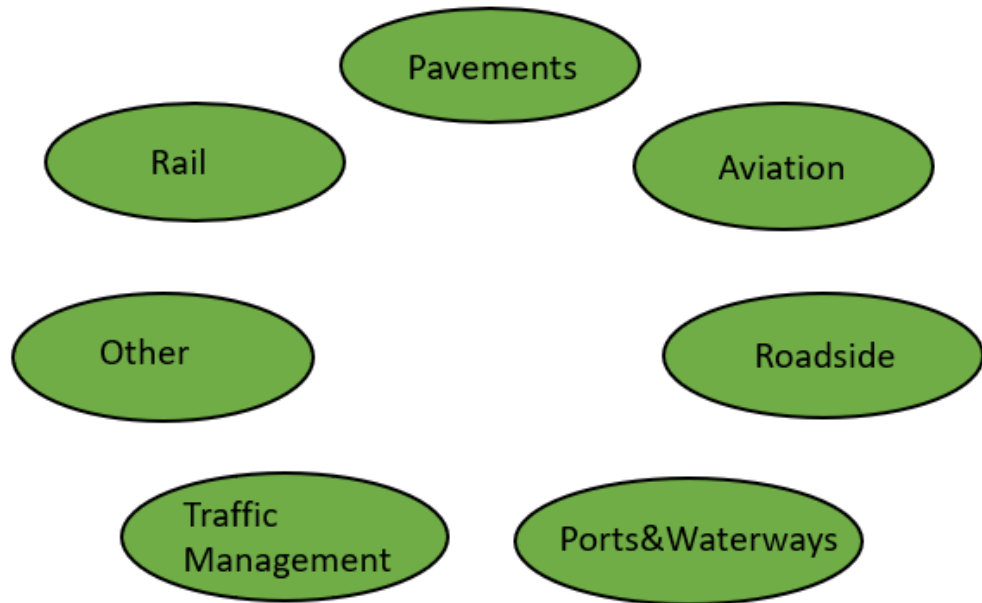
Figure 3. Examples of physical facilities (Adapted from Prescott & Andrews, 2013.)

2.2 Asset management systems and components

According to Chen & Bai (2019), various procedures and components are integrated across asset management systems for improving the decision-making process. System components produce essential information for evaluating potential implications of alternative decisions based on the condition of physical assets, estimated value, and available resources. The Federal Highway Administration recommends the inclusion of the following elements during development of an effective asset management system:

- Asset inventory

- Strategic objectives

- Asset evaluations

- Performance measures based on quantitative information

- Assessment on the performance level of strategic goals

- Relational databases

- Engineering analytical tools

- Budget and resource allocation information

- Constant feedback processes (UIC, 2016)

The illustrated managerial elements can be categorized into five primary groups which are:

- Basic data

- Performance metrics

- Needs assessment

- Program evaluation

- Delivery (UIC, 2016)

Figure 4. sufficiently highlights the individual elements of each group, at the same time describing the perspective of a management system. For instance, policies, objectives, and goals are discussed under the basic data section (UIC, 2016). Assessment of asset condition and necessitated levels of service from rail networks are discussed under the performance metrics. Forecasting and performance modeling coupled with funding assessment comprise the needs analysis section (Abuzayan et al., 2014; Chen & Bai, 2019). On the other hand, program optimization and alternative assessment are identified under the program analysis section. The program delivery area constitutes the program creation and implementation actions towards increased asset value and reliability. Lastly, performance review and feedback development finalize the life cycle of the rail asset management practice (Piryonesi & El-Diraby, 2020). Through this, Finnish rail companies such as VR Group can improve the service life cycle of physical assets and efficiently accomplish stakeholder expectations.
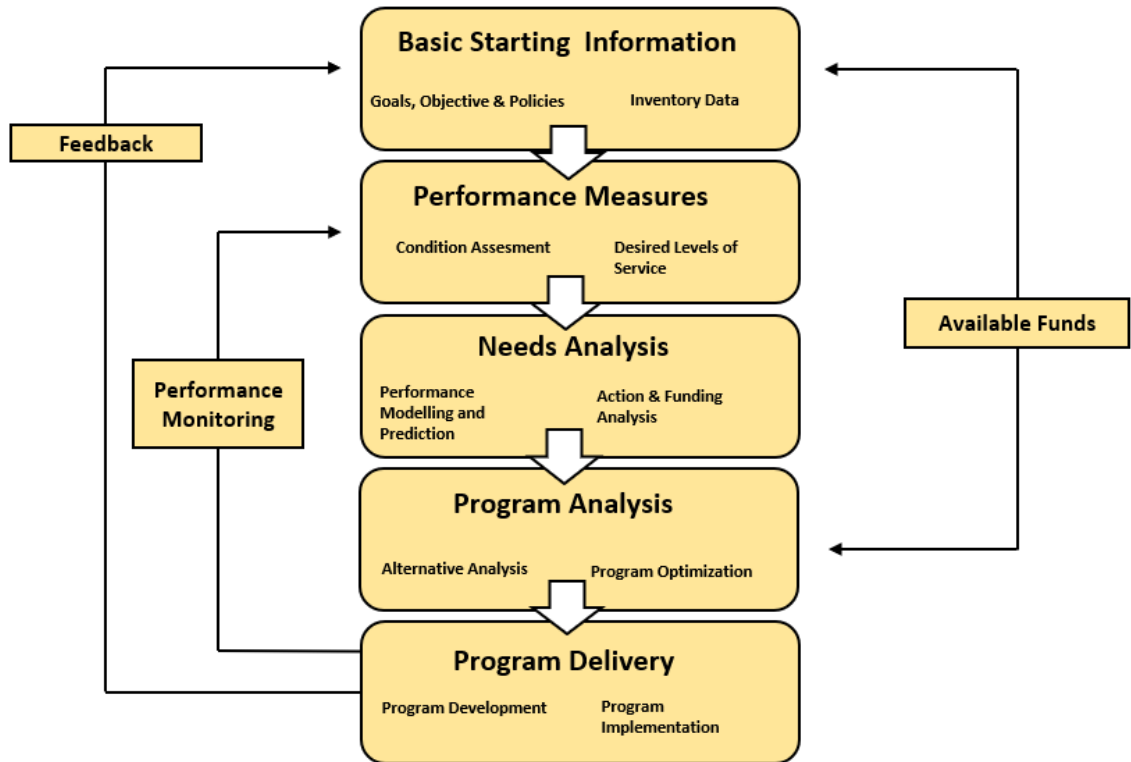
Figure 4. Aspects of an asset management system (Adapted from UIC, 2016)

Effective management of assets necessitates well-defined goals and objectives. The decision-making activity should be founded on a company's policies, goals, and objectives (Maletič et al., 2018; Piryonesi & El-Diraby, 2020). Policies are integrated to establish the most appropriate framework for accomplishing target goals. Various company goals and objectives are expressed during the asset management planning period to promote engineering standards in the company.

Litherland et al., (2021) establish that railway companies store crucial information such as the physical location, expenses, features, resources, and any relevant data under asset inventory. Management systems also provide financial information regarding a company's assets, indicating the contemporary economic value and estimated future value of the assets (Piryonesi & El-Diraby, 2020). Thus, decision-making practices concerned with the form and amount of collected data are based on a company's available resources.

For a rail company to evaluate the situation of its asset network, it necessitates knowledge of the contemporary condition of an asset. In most cases, performance measures are employed to develop achievable company objectives (Litherland et al., 2021). As such, various performance metrics such as condition indices, remaining life of

an asset, and amount of the network system considered to be in good condition enable companies to evaluate the condition of physical assets (Litherland et al., 2021). Consequently, performance metrics are applied to determine the optimal service levels for rail asset networks (Piryonesi & El-Diraby, 2020). Identifying the appropriate level of service is essential in strategy development towards achieving specific goals and objectives (Piryonesi & El-Diraby, 2020).

For rail companies to efficiently project future values of an asset network, they are recommended to integrate various performance frameworks. During planning, organizations should establish asset future requirements to enhance value and reliability (Dehghanian et al., 2012). Appropriately selecting performance models depends on the kinds of assets being managed by a rail company, as well as available information to support the frameworks.

Funding is essential for effective asset management activities. The implications of investment strategies on the value of rail asset networks are evaluated by examining shifts in the current performance aspects (Litherland et al., 2021). Through this, rail companies sufficiently allocate financial resources to asset classes, capable of meeting organizational goals.

Various studies (Dehghanian et al., 2012; Joseph et al., 2018), highlight the need for program assessment of substitute analysis methods for feasible implementation of asset management systems. The development of several analytical tools is fundamental for companies during evaluation of investment impacts on managerial decisions. Most rail companies utilize cost/benefit analysis mechanisms, simulation, database query, risk analysis, and many more methods to assess substitute decisions (Dehghanian et al., 2012; Joseph et al., 2018). Analytical tools assist companies to determine the effect of different managerial decisions. In this case, such tools promote sustainable asset management practices aimed towards achieving stakeholder expectations (Dehghanian et al., 2012; Joseph et al., 2018). Effective program development depends on optimal budget allocation across different asset classes (Joseph et al., 2018). Managerial decisions regarding the fund allocation across diverse company activities, such as modern construction, maintenance, and rehabilitation aim to optimize resource allocation towards realizing established objectives and goals (Joseph et al., 2018).

Effective selection criteria should be implemented to enable organizations to come up with the most sustainable management systems. In addition to engineering mechanisms, asset-centric companies are encouraged to consider economic, social, and political factors to promote effective allocation of resources towards improving asset valuations. The

implementation process should address every component of an asset management system. Major areas such as objective and policy reviews, data collection and analysis, condition evaluation, budget construction, maintenance, performance monitoring, and feedback are described under program implementation (Joseph et al., 2018).

All managerial levels associated with organization decision-making practices must take part in the development of an implementation program. For instance, the integration of a specific management system across the budgeting unit necessitates collective partnerships between the upper management and all members involved in the operation (Gavrikova et al., 2020; Parida et al., 2015). Typically, successful management models support organizational activities by streamlining the availability and functionality of infrastructure. Thus, management effectiveness should be reflected under the corporation savings. The benefits of management systems can only be achieved if all levels conform and adhere to the standards and procedures of the approach (Gavrikova et al., 2020).

This process is essential since it addresses the performance constraints of a system through periodic evaluation of the level of service provided (Parida et al., 2015). Performance review metrics tracks asset productivity over a given period to identify whether the desired level of service is met or not. In this case, rail companies can efficiently detect possible shifts in the asset condition and integrate appropriate corrective measures if necessary (Maletič et al., 2018). Further, the projected volume of service realized from assets can be adjusted depending on the findings acquired from program implementation.

This is the final component of an effective and functional asset management system. Gathered feedback from company stakeholders tends to maximize organizational benefits achieved from the management system (Gavrikova et al., 2020). Continued performance monitoring from the process can develop substantial lessons from improving asset value in the future. Additionally, rail companies can conveniently adjust established policies and objectives based on feedback from stakeholders (Gavrikova et al., 2020). However, managers should remain keen before modifying major components of an asset management model. Multiple or short-term changes can harm system credibility. Asset managing is firmly reliant upon the quality and accessibility of resource information and data. This was a significant worry for the associations overviewed in this venture since every one of them manage critical and profoundly complex actual resource portfolios (Gavrikova et al., 2020).Most distributed writing on asset management makes broad reference to the significance of the subject of information and data the executives, including past reports and work completed inside the company (Maletič et al., 2018; Zuashkiani et al., 2011). As a feature of its Asset Management System (AMS), and in this way inside

its management plan, the company should resolve not simply the subject of the information it needs to help its business, yet additionally to explore the possession, administration, quality confirmation and change the executives (Joseph et al., 2018). Resource information ought to be precise, finished, steady, substantial, on schedule and extraordinary. Data quality is ensured through the following practices as established by Gavrikova et al. (2020).

- Identifying information hazards

- Allocating information jobs and duties

- Information trade prerequisites

- Impact of value, accessibility, and the executives of data on dynamic

- Data credits required

- Data quality necessities

- How and when data is to be gathered, broke down and assessed

- Information the board measures

- Alignment (consistency) of wording

- Consistency and detestability of information in regard of lawful, administrative, partner and hierarchical prerequisites and targets. Subsequently the subject information/data for asset management purposes ought to be drawn closer according to three viewpoints:

- Acquisition measure: key boundaries to gather/measure that help execution of technique and dynamic models: estimation hardware precision: information procurement/investigation approach; estimation/obtaining conditions information design (Zuashkiani et al., 2011).

- Analysis and capacity measure: huge resource portfolios produce large measures of information/data that should be examined and put away such that upholds simple also, proficient access. For this reason, it is generally perceived in the business that there is advantage to be acquired from executing a thorough and incorporated asset management system (Gavrikova et al., 2020; Zuashkiani et al., 2011).

Careful assessment across primary system changes such as prediction frameworks, economic assessment mechanisms, reporting techniques, and database tools is fundamental towards successful management of physical assets (Gavrikova et al., 2020). Throughout, streamlined information sharing between management levels should be maintained to mitigate potential damages to the system (Gavrikova et al., 2020). Therefore, feedback from organizational stakeholders should be supported by comprehensive information to ensure that implemented changes on the model produce positive outcomes.

2.3 Asset and Maintenance Management

Too & Too (2010) indicate that asset management aims to integrate a holistic organization model for realizing specific objectives. Thus, appropriate management of assets promotes continued performance across strategic, operational, and tactical business units (Too & Too, 2010). The fundamental motivation behind this preparation is to adjust the outside labor force to the carried out asset management goals and practices and its intricacy will fluctuate contingent upon the intricacy of the attempts to be performed and their conceivable effect on the asset management procedure/targets (Roda & Macchi, 2018). If the reevaluated administrations/exercises affect accomplishing an association's asset management destinations, the related dangers will be surveyed and those exercises/measures controlled (Love et al., 2018; Petchrompo & Parlikad, 2019; Roda & Macchi, 2018; Simões et al., 2011). In this view, maintenance management refers to the periodic servicing and update of rail assets and related component. These practices are essential for constant business growth regarding operations and productivity.

Mitchell (2007) indicates that the main objective of managing physical assets is to improve their value and return of investment in the long term. In this case, railway companies incorporate physical asset optimization procedures or programs depending on opportunities to enhance asset value across diverse regions. According to Rosqvist et al. (2009), such opportunities can encompass cost reduction in operational activities and enhancement of train capacity and productivity. Successful asset management necessitates optimal collaboration and synergy across operations and maintenance or engineering units. Roda & Macchi (2018) continued that appropriate combination of methods, tools, and disciplines is fundamental for in improving the life cycle of railway asset networks. Various studies view asset management as the decision-making process of asset safety and care. According to Kumar et al., (2013); Yahaya et al. (2018), crucial elements are required in optimizing asset management, including:

- Enhancing production and reliability

- Minimizing operating expenses

- Improving asset effectiveness

- Increasing asset value and quality

- Developing flexible and holistic management systems (Kumar et al., 2013; Yahaya et al. (2018).

These elements are considered by numerous researchers in their discussion on optimal asset management across physical asset companies. Periodic development and improvement facilitate the implementation of business programs for continued optimization of physical assets and enhancement of value and return on investments (Abuzayan et al., 2014).

Maintenance refers to periodic asset servicing and care of related components. The aim of maintenance management of physical assets is to facilitate successful operations and functionality over a prolonged life cycle. These processes can detect potential failure or defects of rail assets and integrating standards for enhancing the effectiveness of activities (Abuzayan et al., 2014).

The information system and quality assurance approach: check reviews, quality established for providers' agreements, framework reports to recognize holes and errors. A powerful system should uphold an association with applicable asset management cycles and exercises, for example, resource stock, arranging, maintenance and upkeep needs, speculation displaying, stockpiling and extra parts, space booking, the executives of resources condition observing, routine support, significant fixes, etc. Overall, it ought to permit the capacity and the executives of all resources related data in an incorporated manner. The subject of Data Quality is another illustration of a space of business which has an ISO standard relevant to it: ISO 8000 Data Quality was distributed in 2011 (Yahaya et al., 2018). It could be especially supposed to be valid in the business that an easy to use and compelling system ought to be gotten to and imagined spatially to have a cross resource view and report resource execution. For instance, the data/information with respect to mishaps that happen in a particular segment, the general climate and geography, the street calculation itself, track surface boundaries and waste conditions on that segment, when seen graphically make multifaceted examination simpler and more instinctive (UIC, 2016). Caring of assets maintain the reliability and capability necessitated by stakeholders. For railway asset networks to deliver efficient services, maintenance management is highly recommended. Various advantages associated with asset-optimization include:

- Reduction of failures

- Increased effectiveness

- Maximizing quality

- Enhancing utilization

- Minimizing incidents

- Lowering the need for repairs

- Reducing operating expenses (Yahaya et al., 2018).

Sustainable cooperation between maintenance and engineering personnel positively impacts asset value, which translates to operational profit. Thus, company management should integrate maintenance across core areas of business, as well as decision-making practices to mitigate possible issues (Tafazzoli, 2017).

Most articles attribute asset deterioration to environmental situations and operational loads, which necessitate periodic maintenance aimed to promote availability and reliability (Tafazzoli, 2017). Further, maintenance management ensures continued adherence to operational standards. A maintenance manager is recommended to apply the following options depending on strategies for effective asset management:

- Rehabilitation of assets is recommended to restore or update the nature of the facility back to an excellent state. For instance, railway companies can profile rail and realign the track to advance functionality (Kumar et al., 2013). This option is reflected under operational costs.

- According to Kumar et al. (2013), the renewal of assets involves structure redevelopment and related components when condition enhancement is needed. For example, railway companies can upgrade worn out rails with contemporary assets. This option is reflected under capital costs (Kumar et al., 2013).

- Asset upgrades entail the reconstruction of facilities to maximize reliability and functionality. Performance metrics are utilized to determine crucial areas for upgrade. For instance, rail companies can replace the structure of the track to conform to modern illustrations (Pärn et al., 2017; Yahaya et al., 2018).

Figure 5. outlines the common life cycle of a rail maintenance management based on asset deterioration of specific periods. Identified graphs reflect the impacts of maintenance operations on performance. Shifts in the resource roughness (representation of asset condition) throughout the life cycle in accordance with amount of traffic in "million gross tones" (MGTs) indicates the implication of maintenance management (UIC, 2016).
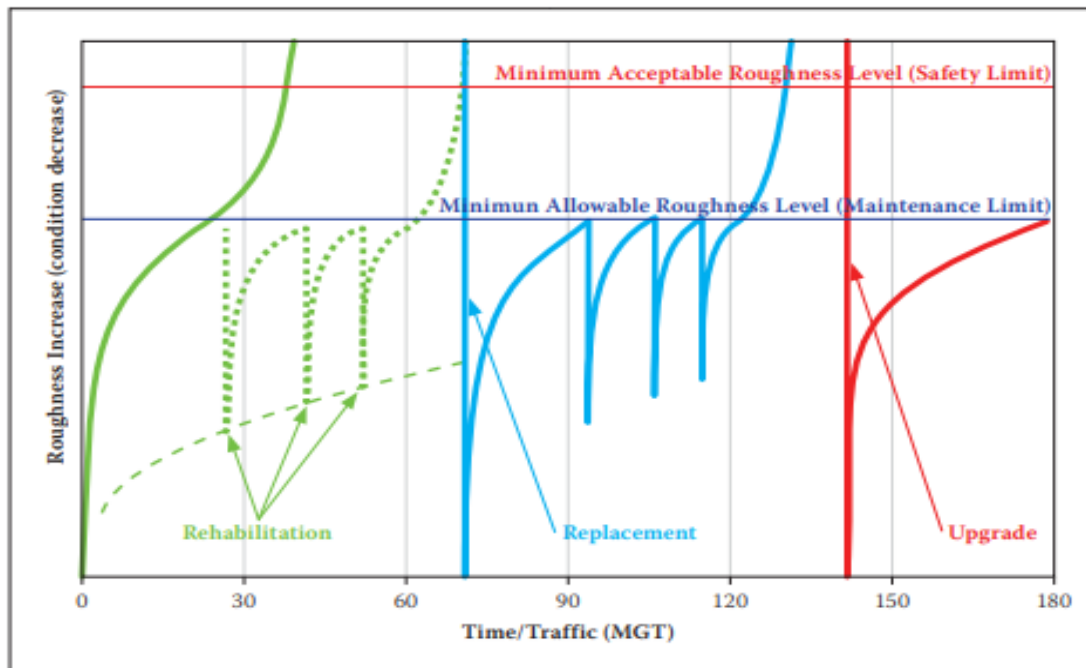
Figure 5. Rail asset deterioration rates (Gavrikova et al., 2020)

The maintenance management process is integral to business activities, especially asset-based companies such as railway corporations. A properly described and documented maintenance protocol enables maintenance managers to accomplish specific objectives and goals of the business (Beitelmal et al., 2017; Pärn et al., 2017). To generate asset value, the maintenance management process follows the following main stages:

- Task identification
- Planning
- Scheduling
- Execution
- Reporting task history
- Performance analysis and feedback (Beitelmal et al., 2017).

Through this, rail companies can effectively promote the decision-making process aimed towards enhancing business value (Pärn et al., 2017).

2.4 Constant Improvement Practice : Efficient Maintenance Management

The established management model for continued maintenance of physical assets is founded on the Theory of Constraints. This theory illustrates that at least a single constraint affects system performance and reliability at a given time (Tafazzoli, 2017). As the management process progresses, the constraints become modified, requiring updates on the response mechanisms. Various studies consider this phase as "constant improvement," in which opportunities are created to enhance the existing asset management strategies and methods (Abuzayan et al., 2014; Gavrikova et al., 2020; Park et al., 2016; Prescott & Andrews, 2013). These phases are incorporated across major maintenance procedures. Maintenance management principles should be clearly analyzed to confirm the fundamentals of the assets. Figure 6. below is a proper definition of constant improvement practice in the asset maintenance management.
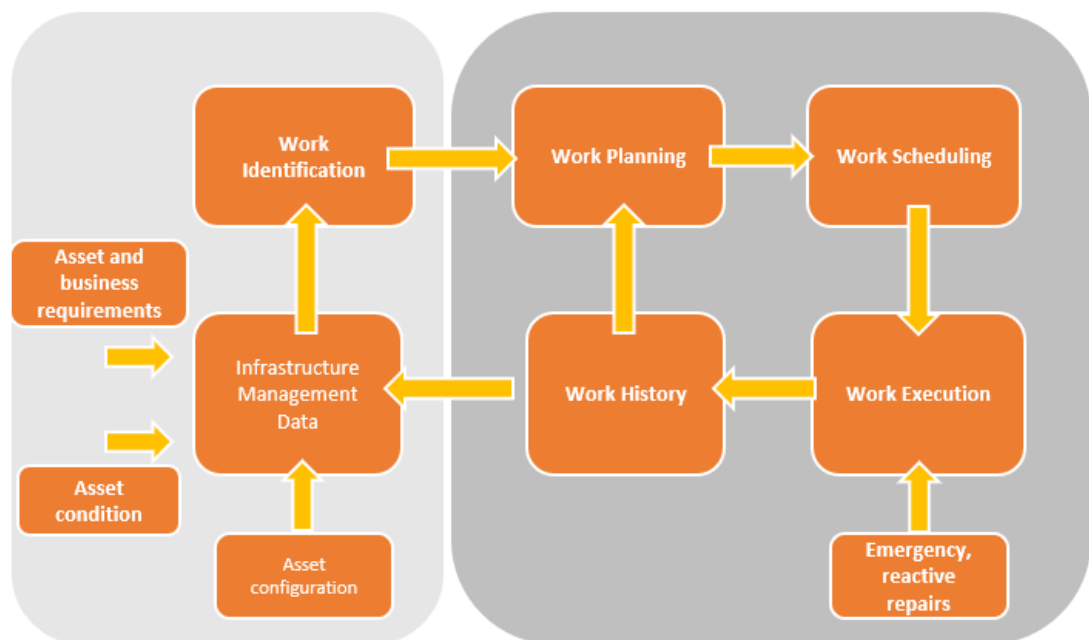

Figure 6. The constant improvement practice in maintenance management (Adapted from Gavrikova et al., 2020)

A collection of maintenance strategies is necessitated to optimize asset management processes. Common maintenance strategies include: Corrective maintenance management; condition-centric maintenance management; and planned maintenance management (Gavrikova et al., 2020).

Shifting from the corrective maintenance strategy to the condition-centric strategy entails several benefits for asset-based companies, including reduced expenses and maximized efficiency. The traditional maintenance strategy recommends response when a defect or failure occurs. In the railway sector, corrective maintenance strategies encompass rail breaks; electrification defects; derailments; removal of substructure elements; and groundwork slips (Kumar et al., 2013).

The strategy focuses on fixing the issue after detection or occurrence. This process increases operational expenses, hence unsuitable for asset management. Furthermore, there are high levels of uncertainty associated with corrective maintenance strategy. Railway companies that incorporate this type of strategy must deal with huge volumes of uncertain encounters, which negatively impact operations. In other instances, corrective maintenance causes production drawbacks, thus limiting the ability to promote service delivery (Kumar et al., 2013).

On the other hand, the preventive maintenance process encompasses both condition-centric and routine-centric strategies. This is the recommended maintenance strategy for railway companies due to its reliability in continued asset management. These maintenance strategies utilize mechanisms that can mitigate possible defects and failure (Kumar et al., 2013). Compared to the corrective maintenance strategy, this advanced process enables managers to eliminate prolonged downtimes by promoting asset capacity and productivity (Prescott & Andrews, 2013). Further, decreased uncertainties in the maintenance process ultimately maximize service provision in the industry. Railway companies integrate routine-centric strategies in terms of periodic intervals, which can be founded on either calendar or operating durations. However, routine maintenance strategies include unprecedented activities which are incapable of enhancing asset availability. As a result, over-maintained physical assets increase operational expenses that do not enhance asset usability and functionality. In the long term, over-maintenance of railway assets can adversely affect operational profits. According to Mitchell (2007), at least 20 percent of asset defects are time-based in the railway industry. With respect to these statistics, around 80 percent of routine maintenance practices are considered inefficient and incapable of mitigating asset failures. In some instances, routine-centric can induce asset defects (Mitchell, 2007).

Due to the issue of over-maintenance associated with the routine-centric maintenance strategy, railway companies prefer the condition-centric strategy, a more advanced and reliable method. This maintenance strategy eliminates the issue of futile over-maintenance and seeks to sustain accurate physical assets' reliability (Kumar et al., 2013).

Thus, increased effective maintenance practices results in optimal asset utilization, increased operational profits, and reduced maintenance expenses in the railway industry.

2.5 Asset-Based Business

According to Van der Westhuizen, (2012), asset-centric businesses highly depend on various asset classes to facilitate operations. Classical businesses classified diverse asset groups into "silos," which focused on asset management issues regarding responsibility groups. However, this process did not consider potential challenges associated with coordination asset class availability for service delivery. Railway companies in Finland encounter greater challenges regarding the various locations that necessitate service provision to consumers. Due to the increased decentralization of railway asset networks, companies encounter complexities associated with the management of operational performance in the transport industry (Cheung & Wong, 2011). Railway companies are the only transport entities that entirely control all the components needed to facilitate transport services, including rolling stock and train infrastructure. Effective asset management in the railway industry necessitates transparency of information conveyed across operations divisions to achieve shared strategic goals and objectives (Cheung & Wong, 2011).

Modern railway companies are encouraged to adopt an integrated and collaborative model to promote performance management across business units. Strategic, operational, and tactical departments should collaborate to ensure continued realization of company goals (Kumar et al., 2013). Researchers recommend the asset-based model illustrated in Figure 7. in which rail companies can integrate maintenance and operations aspects of management system. This model is an improvement of the classical system (silo) to promote effectiveness in the functionality of the organizations (Glasson, 2017). Finnish railway companies such as VR Group are distinguished through higher transparency of managerial data. Such companies efficiently utilize performance information, analytical technologies, and communication channels to facilitate information sharing among internal stakeholders. Additionally, these rail companies enhance timely and transparent asset management during financial reporting and forecasting, to streamline decision-making practices and accomplish company goals (Kumar et al., 2013). In this case, company transition from a silo-based asset management system to a more advanced model requires information transparency, as well as coordination among stakeholders to achieve mutual objectives (Glasson, 2017).
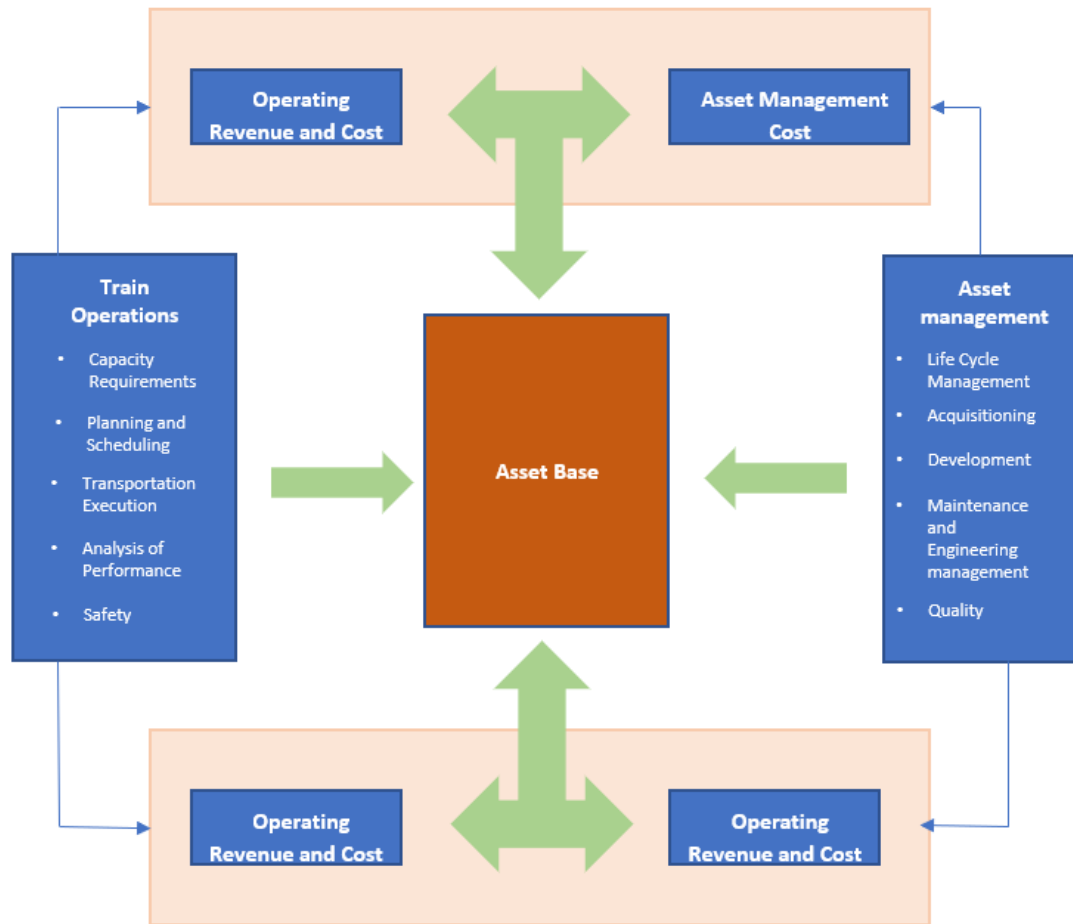
Figure 7. Asset-based business framework (Adapted from Glasson, 2017)

2.6 ISO 55000 Series of Standards and Principles

The following series of asset management standards – "ISO 55000, 55001, and 55002" – establish the principles and guidelines for a productive approach to infrastructure development and maintenance (Glasson, 2017). These sets of standards outline widely acknowledged concepts and aspects for implementing appropriate asset management systems (ISO 55000) highlight the necessities for managing assets (ISO 55001) and guidelines on how to interpret asset management necessities (ISO 55002) (UIC, 2016). Using these standards, railway companies can conveniently address operations performed on the asset management, facilitate appropriate organization strategies for creating value from assets, and coordinate personnel towards enhancing productivity in the company. This series of International Standards are essential in the rail sector since they reflect a worldwide consensus on the perspectives and need for asset management towards enhancing value across different organizations. Since their inception in 2014, the

suite of standards promotes good practices for asset-based organizations and a continuous improvement on the management system. According to ISO 55000 series, an asset refers to anything that demonstrates value to a company (Dehghanian et al., 2012; Glasson, 2017). It may encompass physical infrastructure, as well as intangible assets such as brand identity. In this view, an asset management system describes a collection of interrelated elements of an entity for determining policies and goals for managing assets. An asset management system represents an approach for effectively sustaining asset activity through systematic focus on leadership, value alignment, and objectivity.

As indicated by Glasson (2017), a sustainable asset management system should:

- Promote effective asset management, whereby decision-makers can achieve stability in terms of expenses, risks, and performance metrics.

- Ensure that an organization has the capacity to accomplish set mission, functions, and goals.

- Describe the organization's intention to facilitate asset management activities to company stakeholders.

Such functionalities allow streamlined organization of assets regarding costs and risks throughout their lifecycle to sustain continued performance (Glasson, 2017).

Railway companies are encouraged to consider various principles associated with ISO 55000 series of international standards (UIC, 2016). These principles act as the building blocks for sustainable management of assets and compliance with ISO 55001 requirements.

The following four primary fundamentals are identified for effective management of assets in the rail industry.

- Leadership – effective leadership refers to organizational consideration of individual factors that impact the accomplishment of company objectives and realization of value from the physical assets (Glasson, 2017). This is possible through commitment from top executives to consistently empower, coordinate, communicate, and promote responsibility across the organization (Glasson, 2017).

- Value – to deliver increased asset value to stakeholders, railway companies must sufficiently create, acquire, refurbish, retain, and maintain infrastructure assets. Organizational objectives and goals of the management system should align with asset activities to assure the realization of value after a given duration (Glasson, 2017).

- Assurance – this involves organizational governance for assuring that company assets can deliver the expected value to stakeholders (Dehghanian et al., 2012; Tafazzoli, 2017). For instance, optimal management of company resources in accordance with relevant systems, constraints, and capabilities is necessary for sustainable asset management practices (Dehghanian et al., 2012; Tafazzoli, 2017).

- Alignment – this involves the integration of plans and objectives of the asset management system towards accomplishing stakeholder expectations. Converting organizational goals into asset interventions utilizes risk and information-centric decisions associated with the organizational functionality (Glasson, 2017).

These four fundamentals reflect the essential elements for integrating reliable asset management frameworks across rail companies.

Proper identification and integration of decision-making standards is an essential principle throughout the ISO 55000 series. Appropriate standards for making decisions should demonstrate the organizational context, stakeholder expectations, and the company goals based on available physical assets and their functionality (Glasson, 2017). This process ensures that implemented organizational decisions can deliver asset value to both internal and external stakeholders (Glasson, 2017). Various decision-making standards for effective asset management across railway infrastructure organizations include:

- Consideration of safety risks to users, internal stakeholders, and the public, to safeguard individual and the environment from possible harm associated with asset activities

- Determination of the implication of infrastructure defects and failures on train functionality, which highly varies depending on the route

- Establishment of the effects of rail infrastructure and related interventions on the surroundings

- Evaluating the resilience level of rail assets to weather and climate shifts.

- Assessment of the entire expense requirements and budget constraints throughout the lifecycle of company assets

- Identifying the remaining life of the assets with respect to the contemporary condition and nominal life of the rail infrastructure (Dehghanian et al., 2012).

Based on these decision-making criteria, railway companies can sustainably facilitate asset activity towards realizing company objectives and expectations throughout the entire lifecycle (Dehghanian et al., 2012; Tafazzoli, 2017).

Proper understanding of potential risks, as well as continued management is a global requirement in the ISO 55001 standard. Risk management is essential during the description and integration of the asset management system. When planning asset activity, railway companies are encouraged to identify possible methods for managing risks during operations. ISO 55001 clearly reflects on the risk management guidelines outlined under ISO 31000 (Glasson, 2017). These guidelines are fundamental for railway companies since they define the impacts of uncertainty on company goals and objectives. These uncertainties encompass both opportunities and threats in the rail industry. Like the ISO 55001 standard for sustainable asset management, this document illustrates appropriate models for effective risk management practices (Glasson, 2017). As a result, ISO 31000 is highly recommended since it does not merely guide asset managers on how to manage risks, rather it allows them to implement the most appropriate framework depending on the industry and stakeholder expectations (Glasson, 2017).

Railway infrastructure companies should facilitate strong strategic plans for designing, constructing, and maintaining assets against possible uncertainties, issues, and dangers that can occur during operations (Halfawy, 2008). In this view, the choice of a risk management framework should depend on established threats and opportunities in the rail industry and their impact on organizational objectives and goals. Through this, a company can reliably come up and implement reliable response measures for ensuring continued activities in the event of uncertainties. The recommended risk management framework for railway companies is the ALARP technique which represents "as low as reasonably practicable" (Halfawy, 2008; Tafazzoli, 2017). Based on this model, companies can weigh a risk against the expected outcomes and available resources for managing it. Appropriate implementation of risk management techniques assists rail companies to closely monitor and improve crucial operational areas, including the financial landscape, environmental effects, infrastructure performance, and other critical risks towards realization of stakeholder expectations.

Various studies (Clements & Mancarella, 2018; Ossai et al., 2014; Tafazzoli, 2017), establish several practical guidance assumptions for effective risk management. Most of these statements are applicable during planning, operation, and performance assessment processes of asset management.

- Risk assessment should be performed across all major components of rail asset management from the initiation of company goals to the execution of the network operations. Mostly, railway organizations determine possible risks during strategic decision-making, including the decision on whether to hire asset maintenance personnel or outsource the practices to a third-party entity (Clements & Mancarella, 2018; Ossai et al., 2014; Tafazzoli, 2017). Identified risks become well understood as the risk evaluation progresses across major components of the rail management system and generate a vivid image of the risk profile.

- A risk register is highly recommended for asset-based organizations since it describes a structured profile of potential risks in the business. The register should link every risk to the components of the management system, as well as the source, possibility, repercussions, and control measures. Through this, companies can sufficiently control and prevent the onset of such risks and promote asset value development in the long term (Ossai et al., 2014).

- Researchers also describe the need for a "Corporate Risk Matrix," which demonstrates risk evaluation procedures for quantifying and comparing risks in terms of likelihood and outcomes (Clements & Mancarella, 2018). The illustrated decision-making standards in the previous section can be applied by railway companies to construct a reliable and functional matrix of possible risks. This process assists asset-based companies to continuously size and rank identified risks that can significantly affect company goals, including train productivity and safety. In the rail industry, a two-dimensional model is widely accepted as the main risk matrix. The first dimension represents the possibility or frequency of a situation occurring, while the other involves the implication on company goals should the risk develop (Clements & Mancarella, 2018).

- The amount of details in the risk evaluation process is essential when demonstrating the severity of asset management risks. Advanced and complex methods are employed during risk assessment to ensure clarity in the description and understanding of common risks in business (Chen & Bai, 2019). For instance, railway companies can implement tree analyses to produce sufficient information regarding possible risks across network infrastructure. Sufficient and available information regarding the sources, consequences, and other important risk assessment assist companies to develop sustainable methods for controlling and mitigating asset damages (Chen & Bai, 2019).

- Finally, asset management studies emphasize on the need for prioritizing risk actions to promote balance of expenses, performance, and risk of physical assets. Standard assessment of cost-benefits is appropriate and highly recommended mechanisms of comparing risk outcomes and financial expenses (Clements & Mancarella, 2018; Ossai et al., 2014; Tafazzoli, 2017).

These areas act as functional guidance on precise risk identification and management especially across railway companies.

Due to the complex nature of railway asset companies, it is important for asset managers to clearly define the scope of the implemented management system. This principle enables organizations to align their objectives with the requirements outlined under ISO 55001, towards successful management of assets and related components (Chen & Bai, 2019; Ossai et al., 2014). Defining the scope of an asset management system positively impacts the certification of ISO 55001 and successful maintenance of assets from potential damage and failure. Figure 8. below is an illustration of the association between asset management, system, organization management, and asset portfolio as illustrated under ISO 55000 series of standards (Chen & Bai, 2019; Ossai et al., 2014). However, the figure does not encompass all activities under asset management within the rail industry. Regardless, the outlined relationship influences the accomplishment of corporate objectives and the realization of asset value towards continued service delivery (Ossai et al., 2014).

The main goal of VR Group in is to deliver valued outcomes by stakeholders, clients, and investors using minimal resources and in a sustainable manner. The scope of asset management systems is independently established by rail organizations and can consider the requirements outlined by major stakeholders, such as policy regulators and funders (Clements & Mancarella, 2018; Nielsen et al., 2016). For instance, a major investor in the railway company might necessitate that the company becomes certified with respect to ISO 55001 for a specified duration to facilitate maintain compliance to all clauses highlighted by the standard. This process aims to incorporate company assets and services with the management systems to maintain compliance with the standard across all clauses (Dehghanian et al., 2012).

The following documents complement the ISO 55001 standard and demonstrate key requirements for consistent asset management across railway companies.

- Strategic plan for asset management – first, this document outlines the asset requirements for accomplishing the objectives and mission of a railway corpora-

tion. Second, it covers the implementation procedures for delivering system ca-pacities (Dehghanian et al., 2012). In most cases, railway companies integrate several strategic plans that encompass asset classes and route strategies. It can also entail summarized information on the assets, operations, and competencies that mitigate issues with investments (Dehghanian et al., 2012).

- Asset management policy – this represents a high-level document with the intent of defining managerial commitment towards the integration of the principles of ISO 55000 series (Chen & Bai, 2019; Clements & Mancarella, 2018). In this view, the policy is concerned with good practice across asset-based companies in the rail industry.

- Management plan – the management plans of rail assets are significantly com-plex compared to other industries. In this view, sustainable management plans should include resources, operations, and timelines for achieving corporate goals in the long and short term (Dehghanian et al., 2012). These plans should encom-pass the entire asset lifecycle from inception to disposal. ISO 55001 recommends the implementation of a contemporary information system towards maintaining the viability and performance of rail infrastructure (UIC, 2016).

These statements are described in detail under the specific clauses outlined in ISO 55001. To sustain compliance, the asset management practice across rail organizations should demonstrate effective leadership and governance, as well as sustainable quality management practices for continued enhancement and performance (UIC, 2016).
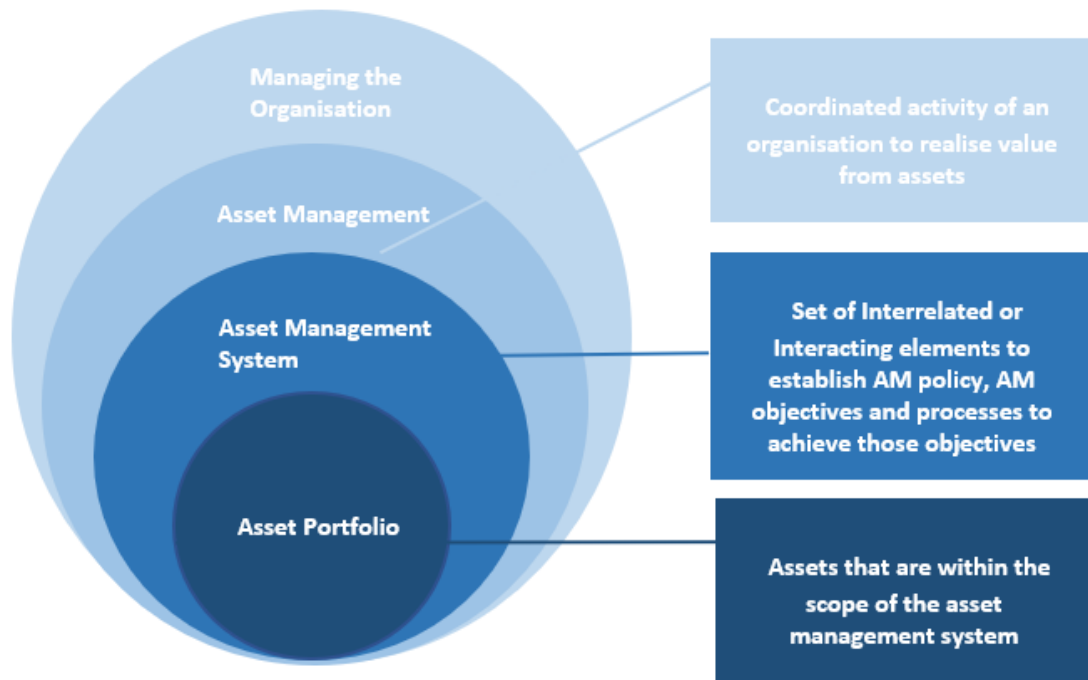
Figure 8. Relationship between an asset management policy and scope of the system (Adapted from Ossai et al., 2014)

2.7 ISO 55001 and Asset Management

As established, ISO 55001 is concerned with the requirements for constructing a reliable and productive asset management system. Therefore, this standard outlines a model for identifying appropriate policies, goals, and governance needed for accomplishing strategic objectives of a company (Glasson, 2017). ISO 55001 applies a systematic approach that facilitates a continuous enhancement and value creation through precise asset-based performance, risk, and expenses. The other two standards (ISO 55000 and 55002) supplement ISO 55001 by highlighting the principles and guidelines for its integration (UIC, 2016). However, this standard cannot be employed to demonstrate financial and technical requirements for asset management since it concentrates on the aspects for a management system. It is fundamental for railway companies to implement the ISO 55001 due to the following reasons established by Glasson (2017):

- Assessment and better comprehension of the company's context and the expectations of the stakeholders. The standards assist asset-based organizations to effectively align stakeholders' ideas of value creation with management goals and objectives aimed to guide the decision-making process.

- Facilitating reliable assistance for sustainable asset management, such as communication, awareness development, and precise allocation of resources.

- Maintaining coordination across the organizational structure, internal stakeholders, technological systems, and employees with respect to operating needs, performance monitoring, and measurement of the management system based on the company's asset portfolio

- Control and organization of organization change management in accordance with the potential risks and opportunities.

- Continued enhancement of products, resources, and services based on collected feedback from organizational stakeholders

- Facilitating efficient integration of asset management practices with other areas, including quality and performance enhancement mechanisms (Glasson, 2017).

With respect to these reasons, railway organizations are highly recommended to comply with the ISO 55001 guideline to enable continued development of a proactive culture and promote efficiency in gaining value from the physical assets. The standard represents contemporary and advanced asset management activities. Creating and incorporating an asset management system using ISO 55001 guidelines insinuates that the company effectively and sufficiently manages operational and capital expenses, risks, and performance (Nielsen et al., 2016; Zuashkiani et al., 2011). The document outlines a widely accepted language for achieving multiple advantages when managing operational assets. Most of these benefits cannot be quantified since they are realized over a given period. During this timeline, ISO 55001 contributes to continued improvement on the company assets and facilitate the realization of value across all operation facets (Nielsen et al., 2016; Zuashkiani et al., 2011).

The presence of an asset management policy and objective in the rail industry is by all accounts basically set off and constrained by contract necessities, instead of by business investigation/assessments. Rail possessing associations (primarily public infrastructure) are bound to have a hierarchical arrangement of policy targets driven by partners and the overall population (Glasson, 2017). It is conceivable hence that associations that are legally obliged to have an asset management policy, technique and cognizant goals for the total asset management start to finish measure, are chipping away at those viewpoints, or have them effectively set up (Parida et al., 2015; Simões et al., 2011; Zuashkiani et al., 2011). The level of associations that have put resources into, or are putting resources into choosing to execute an asset management policy and procedure that could make their business more beneficial, without being compelled to do it by contract, is as yet negligible. To build up an asset management policy and methodology and destinations, an association ought to likewise assess:

- The connection between the asset management policy and targets and the association's general corporate strategies

- That the asset management policy and targets are sufficient for the reasons for a beneficial business, without dismissing the consistence of the material guidelines

- If the asset management policy and targets are written in a manner that is unmistakably perceived by every one of the members in the sector, including the meaning of how the activities of every person in the association's design will contribute towards its accomplishment/achievement; laying out objectives that are significant at each level in the association is significant, yet ought to hold straightforwardness of how they interface undeniable level goals

- If the association has the important assets and skills to accomplish the characterized destinations (Parida et al., 2015)

2.8 Benefits of Implementing ISO 55001

- Performance enhancements – sustainable management of both long term and short-term organizational opportunities increases sustainability, which allow companies to constantly sustain performance and stakeholders' expectations.

- Risk management – the periodic monitoring of procedures and practices promotes the implementation of decisions capable of balancing risk and performance elements for improved asset management (Simões et al., 2011).

- Productive decision-making – integrating an appropriate asset management system enable the development of informed decisions for the coordination and advancement of asset-based operations (Simões et al., 2011). Further, productive decision-making practices align company actions with major organizational goals.

- Cost efficiency – Proper development of sustainable management systems promotes return on investments, as well as mitigates unproductive expenses during the entire life cycle of physical assets.

- Business development and growth – a strong management system assists with formal and prioritization of implementation plans aimed to improve business operations. A sustainable asset management system aids

in effective communication and information sharing among internal and external stakeholders.

- Improved stakeholder confidence – Utilizing the ISO 55001 document and the complementing ISO 55002 demonstrates clear and reliable policies and strategies for facilitating value creation from the physical assets.

The established benefits gained from utilizing ISO 55001 are difficult to quantify and measure since they cannot be realized immediately after the implementation. However, railway companies that integrate this standard during asset management practices accomplish good practice, which acts as the foundation for continued asset improvement and realization of stakeholder expectations (Glasson, 2017). ISO 55001 conveniently combines all operations and activities associated with railway company in a single system, which highlights strategies for maintenance, upgrade, and disposal upon crucial assessment (Zuashkiani et al., 2011). Additionally, it facilitates a myriad of principles and procedures for optimizing asset-based decisions regarding expenses, performance, and risk in the long term. In this case, the standard is designed for asset-centric organizations with a variety of physical infrastructure and is widely applied in the rail industry for continued value development (Glasson, 2017; Hanski et al., 2016).

The standard also provides the way forward for enhancing performance across physical assets utilized by an organization. In addition, it promotes a structured process of optimizing investment decisions for improving stakeholder value at the least expense and justifies the risks associated with asset activities. Finally, ISO 55001 promotes transparent governance of physical assets to mitigate possible inconsistencies in terms of planning, decision-making, and strategic management (Glasson, 2017; Parida et al., 2015). Therefore, a railway company seeking to improve value creation from asset activities should incorporate ISO 55001 to facilitate a foundation for effective management throughout the lifecycle of the assets.

3. RESEARCH METHODOLOGY AND DATA

This study employs a qualitative systematic research, which acts as the primary instrument for the entire study. A qualitative research is founded on theoretical or interpretive models, which describe the research problem ascribing to the thesis. In this qualitative research, various characteristics are considered with respect to the contemporary nature of interpretive studies. The main characteristics of a qualitative research include inductive and deductive reasoning, researcher as the primary instrument, reflexivity, and participants' meaning (Nassaji, 2015; Snyder, 2019). These traits resonate with the process of designing a qualitative research for evaluating the study questions. For the selected qualitative design, a systematic review is the most appropriate methodology for this thesis. It employs explicit practices for identifying, selecting, and appraising relevant study materials from published works associated with the three questions. According to Nassaji (2015), a systematic review refers to a critical analysis of formulated questions through explicit and structured approaches for establishing and evaluating relevant articles. Therefore, the researcher cannot integrate statistical models or meta-analyses to examine the finding of the identified studies. Most researchers consider systematic reviews as 'original empirical materials' since they utilize primary data. This methodology is reliable for appraising the extant literature on a given subject matter since it incorporates results from previous studies investigating a similar problem or question. Almeida and Goulart (2017), indicates that systematic reviews entail three major processes:

- Selecting and evaluating previous published works

- Appraising the study methods

- Synthesizing the results to form an informed discussion.

As a result, the incorporated qualitative systematic review for this thesis is based on rigorous criteria for searching, identifying, and appraising relevant evidence.

The researcher incorporates necessary equipment to collect necessary non-numerical data associated with asset management within the VR Group. According to Creswell & Poth (2018), the researcher is mandated with developing reliable and productive amounts of information for answering the established research questions. In addition, the researcher is encouraged to mitigate potential study and individual biases regarding asset management to maintain the integrity of collected data. Accurate and dependable data collection mechanisms are hence recommended to shift the researcher's focus from

the practice towards the collection activities. Since asset management in the rail company represents the phenomenon of interest in the research, a phenomenological approach of systematic review is incorporated to establish relevant answers for the study (Creswell & Poth, 2018). As such, every section of the study is considered based on the viewpoints of the utilized studies in terms of managing rail company.

The integration of a phenomenological study in the collection of data facilitates the accomplishment of the study significance. In this case, the researcher is considered the primary instrument of the experiment for acquiring empirical information for the study. This qualitative study incorporates comprehensive illustrations that link the research questions to the study objectives (Creswell & Poth, 2018). Additionally, a phenomenological study captures the major themes of the study with respect to individual predispositions. Therefore, the researcher integrates comprehensive systematic review to facilitate reliable and productive data collection mechanisms founded on a specific phenomenon.

As illustrated, a qualitative phenomenological design is implemented for this study. This research is fundamental for the establishment of asset management practices that appropriately reflect various research objectives (Creswell & Poth, 2018). Compared to the quantitative or mixed methods designs of study, the qualitative process seeks to determine relevant responses from the study sample size for better management of rail company and network (Creswell & Poth, 2018). As illustrated by Creswell & Poth (2018), qualitative processes offer the researcher descriptive information that enhances topic understanding. Further, it promotes a holistic perspective throughout the experiment to establish relative value of rail assets. The tenet of a phenomenological research is based on the social elements that consists personal views during the investigation (Creswell & Poth, 2018). Thus, the systematic reviews used were deliberately selected from a wide range of options using inclusion and exclusion criteria. For example, for planning, only published sources were considered to promote the adequacy of data collection practices (Creswell & Poth, 2018). In this sense, a long-term assessment of asset management practices was included to improve data functionality and reliability.

A popular sequence for conducting this research's systematic review is described to indicate how empirical material was acquired for this research's questions and phenomenon (asset management). A well-defined protocol based on the three research questions was employed to explicitly establish information regarding the asset management topic. Various tools and frameworks are considered to guide the entire process.

This systematic review research utilized the following five major stages for acquiring empirical material and implementing the study.

- Review the research questions – Research questions are formulated to guide the qualitative systematic review and should be answerable. The first question – What is the process for determining the fundamentals of asset management for an organization? – is searchable since it seeks to identify processes that rail organizations can acquire the desired level of service to meet stakeholder expectations. The second question – How is the asset management maintenance process ensured? – enables the researcher to evaluate sources for asset-based decision-making that balances risks, expenses, performance, staff productivity, desired service levels, and stakeholder engagement. The third question –What are the main internal and external interfaces of the asset management system? – is answerable since it considers major aspects of asset management such as informational systems and operational processes. These three questions are first reviewed before evaluating them across various networks. Snyder (2019), insinuates that the PICOS (participants, interventions, comparators, outcomes, and study design) framework is used to review the three research questions and the asset management phenomenon. The questions are structured based on PICOS, in which the participants are represented by the VR Group while the study designs encompass comparative research associated with the subject matter of asset management (Snyder, 2019). This framework assists the researcher to summarize and compare published articles concerned with the same intervention for a specific assumption. The objective of this stage is to ensure efficient quality reviews of the questions needed to collect evidence across different management databases.

- Literature sources and searching – the next stage involves the development of search strategy based on established keywords, identification of the study reports, evidence sources, and the inclusion and exclusion criteria. Sufficient retrieval of relevant literature associated with asset management in a Finnish rail company can be challenging due to the sheer volume of available articles. The employed research strategy for this thesis required librarian skills to implement effective searching skills (Liu, 2021). A librarian tends to carefully select keywords and databases when locating and retrieving relevant empirical materials (Liu, 2021). In this view, utilized keywords for acquiring relevant sources include asset management, rail infrastructure management, ISO 55000, ISO 55001, asset management systems, and asset management maintenance. Due to different

methodological application by published articles, the researcher utilized significant journal rankings to select core materials for the systematic review. For instance, "Tuni Andor, Tuni Trepo and Business Source Ultimate" are some of the essential databases employed to derive asset management information and data.

- Critical appraisal of empirical materials – This stage involves an in-depth analysis of the identified pieces of literature to ensure that they adhere to the inclusion criteria. The researcher considered various appraisal tools for determining the strength of identified articles, such as AMSTAR. Nassaji (2015) recommends the AMSTAR tool as the most effective process for identifying the research questions based on the inclusion criteria; performing a reliable literature review using at least two sources; effectively identifying the keywords; and extracting data based on independent extractors. In various instances, the researcher encounters numerous challenges when obtaining validity of the published works (Nassaji, 2015). Therefore, the AMSTAR tool plays a vital role in maintaining the appropriateness of the study practices and mitigating possible publication bias. For instance, it determines whether the authors of the published materials utilized primary data sources or sought additional data from other authors (Talan & Sharma, 2019). This activity should be performed by the researcher and an external reviewer to substantiate the application of scholarly work in the thesis. After the completion of the appraisal process, the investigator and the reviewer reach a consensus, which acts as the basis for decision making concerning the appraised materials.

- Data collection – gathering information using the systematic review approach necessitates a highly structured and disciplined process. This process involves obtaining relevant data associated with asset management in a Finnish company from the appraised studies. This is the literature review process whereby all necessary results conform to the inclusion criteria to develop a body of evidence concerning the three questions (Nassaji, 2015). For instance, only published sources were considered to promote the adequacy of data collection practices. In this sense, a long-term assessment of asset management practices was included to improve data functionality and reliability (Creswell & Poth, 2018). This process employs technique to facilitate an accurate and effective data collection practice.

- Data Synthesis – this represents the final stage of acquiring and appraising empirical materials for analysis. In this stage, the researcher compiles the selected

published articles to create the results of the qualitative systematic review. According to Creswell & Poth (2018) the primary objective of synthesizing collected data is to combine and summarize study outcomes from all empirical materials meeting the criteria. The findings must be summarized in a structured and evidence-based literature section in the thesis. The framework utilized across different literature sections is based on the form of evidence gathered and appraised throughout the research process (Creswell & Poth, 2018). The researcher can utilize thematic synthesis depending on the nature of data acquired to ensure validity and reliability of the findings.

A qualitative systematic review is reliable for examining the phenomenon of interest (asset management) and answering the posed research questions. Data analysis involves organizing summarized information and themes in an interpretive manner for presentation. This qualitative research utilized descriptive analysis of the articles reviewed based on their topic, period of assessment, results, and approach. The aim of descriptive analysis is to discuss the asset management phenomenon and associated features (Buscemi et al., 2006). This thesis is more concerned with what questions and how something has occurred. As a result, the qualitative design of research adopts a holistic process of acquiring relevant data from a variety of databases and sources. Since the research's phenomenon consists adequate empirical data, qualitative design plays an important role in increasing understanding of the asset management practice in a Finnish company. Therefore, the study should report and analyze data qualitatively to better understand modern knowledge and skills in the railway company (Buscemi et al., 2006). Based on the AMSTAR tool, various elements of utilized databases were maintained to ensure successful collection and analysis of data. Using descriptive analysis, the systematic reviews used were deliberately selected from a wide range of options using inclusion and exclusion criteria.

Because the subject of this study contains preliminary empirical data, qualitative design plays an important role in increasing understanding of the financial management phenomenon. Therefore, the study should report and analyze data qualitatively to better understand modern knowledge and skills in the railway company.

According to Creswell & Poth (2018), phenomenological research is relevant because it contains an interesting phenomenon based on individual relationships in the railway environment. In this case, the chosen research design can significantly improve practices and mitigate damage associated with infrastructure failures and disruptions (Creswell & Poth, 2018).

It is fundamental to understand significant ethical considerations that can impact the validity and functionality of the study. Unethical practices during investigation should not be tolerated to sustain usability of collected data.

According to Creswell & Poth (2018), researchers are recommended to adopt means for mitigating possible individual bias during data collection and analysis. To promote data validation, acquired information from the systematic review should stick to the evidence rather than personal assumptions. (Creswell & Poth, 2018).

4. RESULTS

This section outlines the findings acquired from the systematic qualitative analysis, with respect to the ISO 55001 standard within the rail sector.

4.1 Asset management fundamentals

Based on the findings from the systematic review and the qualitative study, the researcher developed a relevant framework for establishing the fundamentals of asset management. As illustrated in Figure 9. below, the purple areas of the diagram represent the major operations and decisions associated with asset management. The decisions and operations flow across strategic and tactical levels of an organization, including transport service delivery to customers. The orange sections reflect the core requirements associated with the 55001 standards (competency, enablers, performance measures, and improvement techniques) (Glasson, 2017). A feedback process is necessitated to promote effective asset management within a company. The grey areas to the right of the diagram align the fundamentals of asset management, such as the strategic management plan and leadership. Based on this framework, the researcher sufficiently developed the process of determining the fundamentals of asset management within VR Group.

Regarding asset management fundamentals, the systematic review and information acquired from the ISO 55001 standard was categorized into two main sections: operational and asset. Regarding strategy, the research established that the process of developing and integrating asset and operational strategies influenced the fundamentals of asset management. Asset strategy was found to mainly encompass the design, maintenance, renewal, enhancement, and disposal of railway company. According to ISO 55001, the researcher established that asset strategies produce reliable evidence for facilitating route objectives at a minimal cost (Glasson, 2017; UIC, 2016). For instance, the intervention process established within asset strategies acts as the link between stakeholder requirements of the asset and the planning process of activities. Compared to other components of the framework, the systematic review identified that strategies remain the main determinant of the expenses and performance aspects of the railway asset (Hanski et al., 2016). On the other hand, the research found out that various fundamentals such as the productivity of VR Group relied on operational strategy. An effective operating strategy determines the requirements for realizing an optimal balance between expenses, risk, and asset performance. In this case, the research identified a positive link

between asset and operational strategies and the fundamentals of asset management within the VR Group.

Evidence was clear on the need for route and delivery plans in the determination of asset management fundamentals. The findings from the systematic review identified that the process of specifying VR Group intervention processes established fundamentals of asset management, including rationalization, refurbishment, and inspection (Raisch, et al., 2009). Such processes are defined under the tactical level of an organization to ensure appropriate planning of organizational operations (Glasson, 2017). Consequently, various studies associate the route operational process with fundamentals in the rail sector.

The process of planning route asset and operations encompass the following processes:

- Description of the route

- Amounts and expenses of maintenance and refurbishment activities

- Work history

- Performance targets and condition of the assets

- Evaluation of the risks associated with the planning fundamental (Hanski et al., 2016).

Consequently, route and access planning processes were found to contribute in the determination of asset management fundamentals within the rail industry. The upkeep the executives cycle comprises of various strategies dependent on condition investigation of the resources (Abuzayan et al., 2014; Chen & Bai, 2019). Two examination models, to be specific the condition-based and condition execution-based models, were presented as a feature of this strategy and brought about techniques that add esteem in deciding preventive and proactive upkeep prerequisites. The creators propose utilizing the two condition investigation models in stages, contingent upon the development level of the rail route's resource the board in utilizing condition-based support arranging rehearses (Hanski et al., 2016). The consequences of the incorporation of the condition-based and condition performance-based support techniques are expanded upkeep adequacy (doing the right things) and subsequently a reduction in support costs (Abuzayan et al., 2014; Chen & Bai, 2019). From this follows less support time, expanded accessibility of resources, esteem adding to the business through expanded accessible limit and, eventually, an increment underway ability. This validates the resource the executives streamlining theory of Mitchell et al., (2007) amplifying profit from venture.

For optimal delivery of transport services, the plans associated with rail network delivery should entail the following processes:

- Provision of a comprehensive design of the network projects.

- Establish the delivery program

- Optimize the provision of infrastructure interventions.

In the case of access planning, the research analysis revealed the need for access planning process for the establishment of asset management fundamentals. Various processes associated with the establishment of access planning include mobilization of the organizational team, equipment, and facilities for commissioning infrastructure functionality.
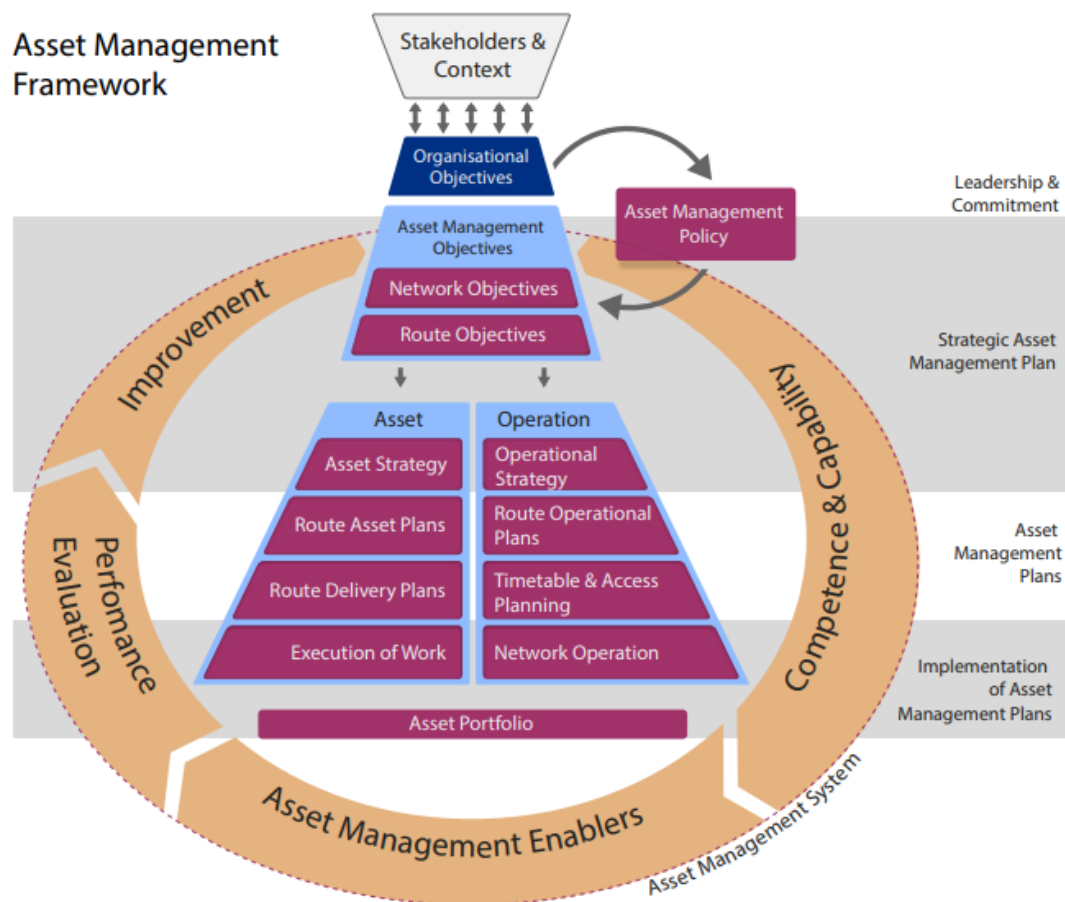

Figure 9. Railway asset management framework (UIC, 2016)

4.2 Ensuring the process of asset management maintenance

Most articles attribute asset deterioration to environmental situations and operational loads, which necessitate periodic maintenance aimed to promote availability and reliability. Further, maintenance management ensures continued adherence to operational standards. A maintenance manager is recommended to apply the following options depending on strategies for effective asset management: Rehabilitation of assets is recommended to restore or update the nature of the facility back to an excellent state. For instance, railway companies can profile rail and realign the track to advance functionality (Chen & Bai, 2019; Zuashkiani et al., 2011). An upkeep the board cycle model was created to help with compelling dynamic on support necessities. The upkeep the board model is alluded to as the Continuous Improvement measure. This cycle guarantees that imperatives and changes are ceaselessly considered, aiding the streamlining of the rail line's resource the executive's interaction (Hanski et al., 2016). It empowers an association to develop the current upkeep techniques constantly further, mediation cutoff points and support measures.

This option is reflected under operational costs: Renewal of assets involves structure redevelopment and related components when condition enhancement is needed (Chen & Bai, 2019). For example, VR Group can upgrade obsolete equipment with contemporary assets. This option is reflected under capital costs: Asset upgrades entail the reconstruction of facilities to maximize reliability and functionality and performance metrics are utilized to determine crucial areas for upgrade. (Raisch, et al., 2009).

Maintenance entails periodic checks, testing, servicing, replacement, and repair of railway infrastructure and related utilities to ensure proper functioning and intended operations of the assets. Ensuring asset management maintenance aims to promote service delivery throughout an asset's life cycle before it develops defects or functional failure. Basically, maintenance is described as asset care to facilitate utilization, maximize effectiveness, reduce failures and operating expenses, and accomplish operational objectives (Kumar et al., 2013). Asset maintenance can either be proactive or reactive. Proactive management encompasses preventive and predictive maintenance activities, incorporated before the occurrence of an event. According to Kumar et al. (2013), preventive maintenance involves scheduled inspections and controls of rail equipment and facilities before any defects or problems arise. Predictive maintenance is the application of sensor equipment for monitoring systems and constantly assessing it based on historical patterns to forecast potential issues before they arise. On the other hand, reactive management of assets entails corrective maintenance, in which malfunctioned and deterio-

rated assets are repaired or replaced (Maletič et al., 2018). These two management categories seek to mitigate asset breakdown, minimize wear, enhance efficiency, and extend asset lifecycle. Proactive measures are more cost-efficient compared to reactive measures. Regardless of the importance of corrective maintenance practices, railway companies should seek to minimize the practices since it results in unprecedented budget expenses that can significantly affect operations and service delivery. In this case, VR Group is encouraged to consider investing in proactive maintenance based on three key strategies. First, the company should renew worn rail with better rail to promote reliability. Second, VR Group can rehabilitate rail tracks, including painting to restore equipment to serviceable conditions. Third, the company can upgrade rail facilities to improve functionality and mitigate unexpected damages and expenses (Gavrikova et al., 2020). Ensuring these asset maintenance processes can significantly prevent asset deterioration and enhance the life of asset materials.

4.3 Internal and external interfaces of the asset management system

ISO 55001 standard highlights the various interfaces that construct a reliable asset management system in form of clauses. From the analysis, each interface is divided into several sub-sections that provide detailed guidance for railway company development. According to ISO 55001, the main internal and external interfaces of VR Group asset management are leadership, operation, support, and improvement.

Subsequently the financial plan for creating asset management is, much of the time, lacking to subsidize the assets (human and monetary) important to carry out every one of the necessary cycles and to incorporate the total and vital arrangement of resource information and data on the dynamic interaction (Hanski et al., 2016).

It can likewise be summed up that the significant regions to put resources into to execute a system agreeable with ISO 55001 are:

- Development and arrangement of cycles and techniques to design, carry out, survey that's more, keep up with the system

- Having the essential qualified and skillful assets to design and deal with the resources over the entire lifecycle, drove from the top level in an association

- Implementing a successful asset management correspondence measure between the pertinent partners

- Improving the abilities of individuals required at all levels

- Implementing and keeping an appropriate undertaking resource the executive's framework that satisfies business needs supporting the activities (fixes and up-keep works) that the asset management cycles will distinguish as important, considering all lifecycle expenses

- Improving information such that better backings dynamic

- Implementing a danger-based way to deal with all asset management choices

- Ensuring a nonstop improvement and change the management interaction (Abuzayan et al., 2014; Chen & Bai, 2019).

It appears to be proper to accept that, if an association has as of now contributed (or plans to contribute) important assets to execute such a system, the negligible additional expense for that interaction of applying for ISO 55001 accreditation, would bode well. The viewpoint of ISO 55000 confirmation relies upon the rail practices within a given area. The end-to-end resource the executives cycle stumbles into every one of these associations and necessities contributions from each regardless of whether just one association is tightening certificate (each can be ensured freely).

Models include:

- Rail authority

- Operator, zeroing in on the genuine conveyance of resource the executives instead of checking of execution. Administrations are less adaptable to move towards accreditation or are not drawn into this kind of standard since they need to manage various project workers (Abuzayan et al., 2014; Chen & Bai, 2019). The advantage of certificate increments with the level of association of the VR Group.

For a rail asset manager dealing with their production network through an execution contract, the advantage could be negligible, basically by having consolation that their project workers are agreeing with it however not working on the general worth of the resources. Carrying out ISO 55001 requires an interest in a significant degree of mindfulness/information about:

- How the ISO standard methodologies resource the executive's framework?

- What are the holes between the association's asset management cycle/framework and what is needed by the norm?

- The requirement for senior-level purchase in from the beginning

- What are the important ventures to close the limits?

- What are the normal advantages from executing ISO-55000?

The research analysis considered the leadership clause as crucial interface for sustainable management of VR Group. Leadership is associated with the top organizational levels, committed to achieving relevant organizational goals and objectives. Top management in the VR Group railway company is comprised of the chief executive officer, the board, and authorization body of the management system (VR Group, 2021).

The various departments of the VR Group are headed by the director of maintenance and operations, director of engineering, and director of asset management (VR Group, 2021). Authority firmly affects how the hierarchical culture is assembled, its sort and on the off chance that it upholds the conveyance of good asset management. Albeit the nature of a company's administration, experience and ability on asset management are not viewpoints simple to see from answers to a survey, it is a key factor, for the execution of a system as well as for its proceeded with effective activity.

The underlying expenses of receiving another framework are fundamentally because of the way that, in numerous companies, there is an absence of asset management culture and involvement with' the top administration level. As an outcome, asset management on projects is for the most part did not draw closer in an incorporated manner, yet rather centers just around a couple of parts of the asset management cycle. In rundown, the examination demonstrates that utilization of the condition investigation models will build the adequacy of the upkeep the executive's interaction.

By executing a condition-based and condition performance-based upkeep procedure, the rail companies can accomplish an absolute support cost decrease of roughly 17 percent and an increment in resource accessibility of around 30 percent (Chen & Bai, 2019). Previous studies show that when railway organizations provide conditional and maintenance-based support, they can set aside a significant part of the maintenance costs and extend the limit at about the same rate (Chen & Bai, 2019).

Recommended practices within this interface include ownership clearance, continued enhancement of the asset management, and directing corporate vision towards the realization of organizational goals (Hanski et al., 2016). In this view, the initial sub-section of the leadership interface entails commitment from the top management to facilitate organizational goals. The second category within the leadership interface is the asset management policy.

According to ISO-55001, policies ensure good organizational practice by providing statement of intent by the top management group. For the railway company to sustain sustainable policies, communication between the leadership and stakeholders is important. The research found out that awareness of the policy, especially among internal stakeholders played a vital role in enhancing the efficiency of asset management practices (Zuashkiani et al., 2011). The ISO 55001 standard outlined the process for developing, reviewing, and updating the policy process of essential railway network routes. Finally, the research examines various organizational responsibilities and functions associated with the leadership interface. To facilitate effective management of railway infrastructure, leaders must understand their specific roles in ensuring compliance with the standard (Raisch, et al., 2009).

Based on a contextual study of analyzes, the study found that the Finland five biggest industrial companies have all arranged their interest in asset management parts of their hierarchical construction. This by itself won't ensure that asset management is considered at all levels of a company so additionally consider whether the current initiative can exhibit business the board skills and in the event that they cover all abilities which incorporate asset management perspectives. This angle was distinguished in this task as a basic achievement factor. An organizational structure should be designed in a way that it enhances the company's capacity to accomplish specific goals and objectives (Hanski et al., 2016). Specifically, the study results recommend the devolution and centralization of asset management practices to promote effective coordination of functions. In addition, VR Group are encouraged to recruit responsible, competent, and accountable individuals to ensure asset performance and minimize associated expenses and risk.

The results revealed the importance of the operation interface during planning and control of rail infrastructure. ISO 55001 emphasize on the need for establishing all functions undertaken by a rail company to successfully integrate asset management controls and plans (Abuzayan et al., 2014; Chen & Bai, 2019). As established by the clause, various design, construction, and maintenance activities represent the major operations performed by railway organizations. Primarily, business operations consist of information, technological capabilities, and capabilities within a railway company (Men, 2014). These operations are necessary for the VR Group to appropriately describe the various inputs and outputs associated with asset components and demonstrate the key stakeholders of these inputs and outputs. Operation's key output includes accountabilities and roles among members.

Settling on the best answer for an asset management will rely upon the company´s methodology and assets, and, partially, heritage frameworks. The force in present day IT

frameworks permits close to ongoing multifaceted investigation to distinguish elective mediation methodologies – allowing for the resource specialists to think about alternatives and upgrade activity plans inside spending limitations.

Since it is individuals that play out the resource the executives work on the ground, their insight, skills, experience, inspiration, collaboration limit, arrangement with destinations and demeanor (proactive/uninvolved), tremendously affect the asset management results. The finishes of this undertaking showed that human resource are a vital space of worry of the partaking associations, on the grounds that mostly the individuals who as of now have the ISO 55001 endorsement, or are headed for the accreditation, know about the prerequisites for solid administration and staff capabilities to be set up and reliably illustrated (Hanski et al., 2016; Men, 2014; Zuashkiani et al., 2011).

This is especially obvious on companies that have broad re-appropriating tasks. It tends to be seen from the contextual analyses that if companies coordinate and permit their interior asset management labor force to partake at proper and regular instructional courses, performed by qualified and experienced mentors and zeroed in on the improvement of asset management abilities, it propels, works on functional information and skills, and permits the chance to line up with an association's asset management system and goals. It likewise coordinates cross departmental groups (Hanski et al., 2016).

5. SUMMARY

5.1 Key findings

This research integrates the ISO 55001 standard, which focuses on asset management practices and requirements in VR Group. This document is fundamental for the company since they reflect a worldwide consensus regarding the defining of asset management and how it can be applied to enhance asset value generated by the company. ISO 55001 describes the components of an effective asset management system, capable of increasing value at the lowest cost possible (Litherland et al., 2021; Men, 2014).

There were three research questions:

RQ1: What is the process for determining the fundamentals of asset management for an organization?

Proper management of assets promotes organizational objectives of output performance by transforming company targets into better strategies, plans, and decisions. Further, strategic benefits of appropriate asset management include enhanced understanding and management of risk, enhanced governance, increasing return on investment, optimized operations, and incremental reliability and performance (Men, 2014). The company stores crucial information, such as expenses, resources, and any relevant data under the asset inventory. Using this standard, VR Group can conveniently address operations performed on the asset management, facilitate appropriate organization strategies for creating value from assets, and coordinate personnel towards enhancing productivity in the company. Management systems also provide financial information regarding a company's assets, indicating the contemporary economic value and estimated future value of the company assets (Zuashkiani et al., 2011). Thus, decision-making practices concerned with the form and amount of collected data are based on a company's available resources. For a VR Group to evaluate the situation of its asset network, it necessitates knowledge of the contemporary condition of an asset. In most cases, performance measures are employed to develop achievable company objectives. As such, various performance metrics such as condition indices, remaining life of a rail asset, and amount of the network system considered to be in good condition enable companies to evaluate the condition of physical assets. Consequently, performance metrics are applied to determine the optimal service levels for rail asset networks. Identifying the appropriate level of service is essential in strategy development towards achieving specific goals and objectives. This document outlines the asset requirements for accomplishing the objectives

and mission of a railway corporation (Litherland et al., 2021). Second, it covers the implementation procedures for delivering system capacities. In most cases, huge railway companies integrate several strategic plans that encompass asset classes and route strategies. In this view, the policy is concerned with good practice across asset-based companies in the rail industry (Litherland et al., 2021).

Four major fundamentals are identified for effective management of assets in the rail industry based on the illustrated process:

- Leadership – effective leadership refers to organizational consideration of individual factors that impact the accomplishment of company objectives and realization of value from the physical assets (Glasson, 2017). This is possible through commitment from top executives to consistently empower, coordinate, communicate, and promote responsibility across the organization (Glasson, 2017);

- Value – to deliver increased asset value to stakeholders, railway companies must sufficiently create, acquire, refurbish, retain, and maintain infrastructure assets. Organizational objectives and goals of the management system should align with asset activities to assure the realization of value after a given duration (Glasson, 2017).

- Assurance – this involves organizational governance for assuring that company assets can deliver the expected value to stakeholders (Dehghanian et al., 2012; Tafazzoli, 2017). For instance, optimal management of company resources in accordance with relevant systems, constraints, and capabilities is necessary for sustainable asset management practices (Dehghanian et al., 2012; Tafazzoli, 2017).

- Alignment – this involves the integration of plans and objectives of the asset management system towards accomplishing stakeholder expectations. Converting organizational goals into asset interventions utilizes risk and information-centric decisions associated with the organizational functionality (Glasson, 2017).These four fundamentals reflect the essential elements for integrating reliable asset management frameworks across rail companies.

RQ2: How is the asset management maintenance process ensured?

As illustrated by Piryonesi & El-Diraby (2020), the main purpose of efficient asset management practices is to facilitate appropriate decision-making processes to assist organ-

ization maximize value through their physical resources. Proper management of rail assets promotes organizational objectives of output performance by transforming company targets into better strategies, plans, and decisions (Piryonesi & El-Diraby (2020).

The series of International Standards are essential in the rail sector since they reflect a worldwide consensus on the perspectives and need for asset management towards enhancing value across different organizations. Since their inception in 2014, the suite of standards promotes good practices for asset-based organizations and a continuous improvement on the management system (Men, 2014).

According to ISO 55000 series, an asset refers to anything that demonstrates value to a company. It may encompass physical assets, as well as intangible assets such as brand identity. In this view, an asset management system (AMS) describes a collection of interrelated elements of an entity for determining policies and goals for managing assets. ISO 55001 should be crucial for VR Group since they reflect a worldwide consensus regarding the defining of asset management and how it can be applied to enhance asset value generated by the company. ISO 55001 describes the components of an effective asset management system, capable of increasing value at the lowest cost possible. It can also entail summarized information on the assets, operations, and competencies that mitigate issues with investments. Policy represents a high-level document with the intent of defining managerial commitment towards the integration of the principles of ISO 55000 series (UIC, 2016). The standard is designed for rail organizations with significant physical assets to ensure value creation in the long term. The main purpose of efficient asset management practices is to facilitate appropriate decision-making processes to assist organization maximize value through their physical resources. Proper management of rail assets promotes organizational objectives of output performance by transforming company targets into better strategies, plans, and decisions (Tafazzoli, 2017; Zuashkiani et al., 2011).

Further, strategic benefits of appropriate asset management of rails include enhanced understanding and management of risk, enhanced governance, increasing return on investment, and optimized operations. The established documents complement the ISO 55001 standard and demonstrate key requirements for consistent asset management across railway companies. Management plans of rail assets are significantly complex compared to other industries (Tushman & O'Reilly, 1996). In this view, sustainable management plans should include resources, operations, and timelines for achieving corporate goals in the long and short term. These plans should encompass the entire asset lifecycle from inception to disposal. ISO 55001 recommends the implementation of a

contemporary information system to sustain the viability and performance of the rail company's asset management.

RQ3: What are the main internal and external interfaces of the asset management system?

To facilitate efficiency of asset operations, incorporated systems across rail infrastructure organizations should demonstrate effective leadership and governance, as well as sustainable quality management practices for continued enhancement and performance. As established, ISO 55001 is concerned with the requirements for constructing a reliable and productive asset management system (Marzouk & Osama, 2017). Therefore, this standard outlines a model for identifying appropriate policies, goals, and governance needed for accomplishing strategic objectives of a company. ISO 55001 applies a systematic approach that facilitates a continuous enhancement and value creation through precise asset-based performance, risk, and expenses. The other two standards (ISO 55000 and 55002) supplement ISO 55001 by highlighting the principles and guidelines for its integration (UIC, 2016). However, this standard cannot be employed to demonstrate financial and technical requirements for asset management since it concentrates on the aspects for a management system. It is fundamental for railway companies to implement the ISO 55001 due to the following reasons: Assessment and better comprehension of the company's context and the expectations of the stakeholders (Zuashkiani et al., 2011). The standards assist asset-based organizations to facilitate reliable assistance for sustainable asset management, such as communication, awareness development, and precise allocation of resources and coordination across the organizational structure, internal stakeholders, technological systems, and employees with respect to operating needs, performance monitoring, and measurement of the management system based on the company's asset portfolio.

The standard is designed for rail organizations with significant physical assets to ensure value creation in the long term. The main purpose of efficient asset management practices is to facilitate appropriate decision-making processes to assist organization maximize value through their physical resources (Hanski et al., 2016; Tushman & O'Reilly, 1996).

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store crucial information such as the physical location, expenses, features, resources, and any relevant data under asset inventory. Using this standard, VR Group can conveniently address operations performed on the asset management, facilitate appropriate organization strategies for creating value from assets, and coordinate personnel towards enhancing productivity in the company. Management systems also provide financial information regarding a company's assets, indicating the contemporary economic value and estimated future value of the company assets (Zuashkiani et al., 2011). Thus, decision-making practices concerned with the form and amount of collected data are based on a company's available resources.

For a VR Group to evaluate the situation of its asset network, it necessitates knowledge of the contemporary condition of an asset. In most cases, performance measures are employed to develop achievable company objectives. As such, various performance metrics such as condition indices, remaining life of a rail asset, and amount of the network system considered to be in good condition enable companies to evaluate the condition of physical assets. Consequently, performance metrics are applied to determine the optimal service levels for rail asset networks. Identifying the appropriate level of service is essential in strategy development towards achieving specific goals and objectives.

This document outlines the asset requirements for accomplishing the objectives and mission of a railway corporation (Litherland et al., 2021). Second, it covers the implementation procedures for delivering system capacities. In most cases, huge railway companies integrate several strategic plans that encompass asset classes and route strategies. In this view, the policy is concerned with good practice across asset-based companies in the rail industry (Litherland et al., 2021).

This series of International Standards are essential in the rail sector since they reflect a worldwide consensus on the perspectives and need for asset management towards enhancing value across different organizations. Since their inception in 2014, the suite of standards promotes good practices for asset-based organizations and a continuous improvement on the management system (Men, 2014). According to ISO 55000 series, an asset refers to anything that demonstrates value to a company. It may encompass physical assets, as well as intangible assets such as brand identity. In this view, an asset management system (AMS) describes a collection of interrelated elements of an entity for determining policies and goals for managing assets.

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et al., 2011). The standards assist asset-based organizations to facilitate reliable assistance for sustainable asset management, such as communication, awareness development, and precise allocation of resources and coordination across the organizational structure, internal stakeholders, technological systems, and employees with respect to operating needs, performance monitoring, and measurement of the management system based on the company's asset portfolio.

5.2 Practical recommendations

VR Group should facilitate strong strategic plans for designing, constructing, and maintaining assets against possible uncertainties, issues, and dangers that can occur during operations (Piryonesi & El-Diraby, 2020). Strategic, operational, and tactical departments should collaborate to ensure continued realization of company goals. Nielsen et al., (2016) recommend the asset-based model whereby rail companies can integrate maintenance and operations aspects of management system. This model is an improvement of the classical system to promote effectiveness in the functionality of the organizations. Additionally, these rail companies enhance timely and transparent asset management during financial reporting and forecasting, to streamline decision-making practices and accomplish company goals. In the long term, over-maintenance of railway assets can adversely affect operational profits. Around 80 percent of routine maintenance practices are considered inefficient and incapable of mitigating asset failures (Abuzayan et al., 2014; Chen & Bai, 2019). In some instances, routine-centric can induce asset defects (Nielsen et al., 2016).

As illustrated by Piryonesi & El-Diraby (2020), the main purpose of efficient asset management practices is to facilitate appropriate decision-making processes to assist organization maximize value through their physical resources. Proper management of rail assets promotes organizational objectives of output performance by transforming company targets into better strategies, plans, and decisions (Piryonesi & El-Diraby (2020).

VR Group is recommended to implement the following actions aimed to enhance its rail infrastructure management and facilitate prolonged asset life cycle:

- VR Group should facilitate strong strategic plans for designing, constructing, and maintaining assets against possible uncertainties, issues, and dangers that can occur during operations (Piryonesi & El-Diraby, 2020).

- ISO 31000 is highly recommended since it does not merely guide asset managers on how to manage risks, rather it allows them to implement the most appropriate framework depending on the industry and stakeholder expectations. Like

the ISO 55001 standard for sustainable asset management, this document illustrates appropriate models for effective risk management practices.

- Recommended practices within this interface include ownership clearance, continued enhancement of the asset management, and directing corporate vision towards the realization of organizational goals. In this view, the initial sub-section of the leadership interface entails commitment from the top management to facilitate organizational goals. The second category within the leadership interface is the asset management policy. Various studies highlight the need for program assessment of substitute analysis methods for feasible implementation of asset management systems. The development of several analytical tools is fundamental for companies during evaluation of investment impacts on managerial decisions (Abuzayan et al., 2014; Chen & Bai, 2019).

- Strategic, operational, and tactical departments should collaborate to ensure continued realization of company goals. Nielsen et al., (2016) recommend the asset-based model whereby rail companies can integrate maintenance and operations aspects of management system. This model is an improvement of the classical system to promote effectiveness in the functionality of the organizations.

- Additionally, VR Group is recommended to enhance timely and transparent asset management during financial reporting and forecasting, to streamline decision-making practices and accomplish company goals. In the long term, over-maintenance of railway assets can adversely affect operational profits. Around 80 percent of routine maintenance practices are considered inefficient and incapable of mitigating asset failures (Abuzayan et al., 2014; Chen & Bai, 2019). In some instances, routine-centric can induce asset defects (Nielsen et al., 2016).

- An organizational structure should be designed in a way that it enhances the company's capacity to accomplish specific goals and objectives. Control and organization of organization change management in accordance with the potential risks and opportunities. Continued enhancement of products, resources, and services based on collected feedback from organizational stakeholders. Facilitating efficient integration of asset management practices with other areas, including quality and performance enhancement mechanisms. Specifically, the study results recommend the devolution and centralization of asset management practices to promote effective coordination of functions.

- The rail company is encouraged to incorporate physical asset optimization procedures or programs depending on opportunities to enhance asset value across

diverse regions. Such opportunities can encompass cost reduction in operational activities and enhancement of train capacity and productivity. Successful asset management necessitates optimal collaboration and synergy across operations and maintenance or engineering units. Appropriate combination of methods, tools, and disciplines is fundamental for in improving the life cycle of railway asset networks (Nielsen et al., 2016).

5.3 Assessment and limitations of the research

Possible types of bias were established from the qualitative systematic review. These errors result in the inclusion of findings and conclusions of research materials without sufficient consideration of the evidence. The initial form of bias established in the thesis is associated with the PICOS review design. When reviewing the research questions, the researcher focused only on one form of intervention associated with positive outcomes of the study (Millett, 2011). This process indicates traces of preconceived assumptions regarding the impacts of infrastructure management in a Finnish railway company. Second, there was potential bias when locating and retrieving relevant empirical materials for the research. When utilizing the inclusion and exclusion criteria, the researcher limited reviewed studies to constraints including publication year and the geographical setting of the study. Furthermore, the search was restricted to several databases, which could negatively affect the reliability of evidence. This limitation on the systematic review indicates that the research was more inclined towards evaluating the positive outcomes of rail asset management rather than an accurate interpretation of the entire study evidence (Buscemi et al., 2006; Millett, 2011). These two forms of bias significantly affect the validity of collected evidence and should be addressed to ensure the reliability and accuracy of results.

Based on the illustrated forms of bias encountered in the research, various limitations of the systematic review encompass the selection of studies. Incorporated articles utilized inclusion and exclusion criteria, which sought to eliminate various published documents based on their publication period and geographical setting. Utilized databases cannot be fully considered comprehensive due to lack of full-text coverage for various documents. Since the thesis mainly addressed asset management in a Finnish rail company, several reviews failed to provide necessary summaries and design characteristics outside the area of interest. This process led to assessment limitation of the totality of evidence associated with infrastructure management in Finland.

Nevertheless, the implementation of the study positively impacted the environment by ensuring trustworthiness and qualitative validity of the findings.

Four elements are utilized to evaluate the trustworthiness and validity of the results:

- Credibility – The credibility aspect involves assessing the usability of the findings from the researcher's perspective. The researcher-maintained credibility of data collected and analyzed, as well as the subsequent findings through accomplishing a specific research protocol. The systematic review incorporated induction meetings with relevant parties and pilot reviews of empirical materials. Furthermore, steps were taken to increase the researcher's authority throughout the study. As the main instrument of the thesis, various individual characteristics of the researcher must be maintained (Almeida & Goulart, 2017). The researcher adequately familiarized themselves with the research context and phenomenon of asset management in rail organizations. Second, the researcher had previously conducted a qualitative data collection using empirical material from relevant databases. Third, he had significant theoretical expertise in conceptualizing various datasets for qualitative analysis using software tools and skills. Finally, the researcher portrayed the capability to integrate a multidisciplinary approach of interpreting results (Snyder, 2019). Regardless of the study limitations, this researcher characteristics maintained the consistency and credibility of collected and analyzed empirical data.

- Transferability – This aspect represents the generalization level of the findings in relation to different contexts and settings. The qualitative researcher facilitated the transferability of the findings by rigorously assessing necessary empirical material within the Finnish railway company context. As illustrated in the methodology section, the utilized inclusion and exclusion criteria ensured that selected empirical materials represented a wide range of perspectives regarding rail asset management in Finland (Litherland et al., 2021). These criteria were crucial for facilitating comparative analysis across diverse settings. Consequently, the thick description technique played a vital role in accomplishing a significant level of research validity. Through this, the researcher reviewed the literature in sufficient detail to analyze the extant materials to which summaries and conclusions are transferable to different locations, periods, and situations. In this case, the findings are transferable to similar research contexts and applicable for future research.

- Dependability – Research dependability is associated with the level of reliability and accuracy of findings. This aspect seeks to evaluate whether the researcher can replicate same results after observing and measuring the same thing twice. To facilitate consistency and accuracy of data, the researcher recorded all revisions made on the research protocol to facilitate a traceable practice of how changes were integrated. Specifically, the investigator employed an inquiry audit for tracking the entire process. The audits were based in the assumption that the reality of the results could be accounted by an external or outside investigator. Due to the bias encountered when locating and retrieving empirical materials, an external auditor can fail to share a mutual point of view with the researcher (Talan & Sharma, 2019). Therefore, enhancing the dependability of future research on asset management in a Finnish company recommends the integration of an analyst team capable of resolving possible discrepancies in the study.

- Confirmability – The final aspect seeks to evaluate the degree to which the finding can be corroborated by other researchers. Nassaji (2015), establish that irrespective of the unique perspective of a qualitative research, one can employ various strategies to promote confirmability. The researcher utilized the triangulation technique by considering three crucial processes: methodology, source of information, and theoretical triangulation. First, the methodology triangulation sought to examine results' consistency using various data collection methods. Second, sources triangulation evaluated sources' consistency from different databases using the same method. As a result of the inclusion/exclusion criteria, employed pieces of literature were compared against each other to establish validity of information regarding rail asset management (Nassaji, 2015). Finally, numerous theoretical assumptions were considered when interpreting and answering the research questions. These three processes promoted the validity of information regarding their confirmability across multiple tests.

5.4 Further Research

For future studies, the preventive maintenance process is encouraged which combine both condition-centric and routine-centric strategies. This is the recommended maintenance strategy for railway companies due to its reliability in continued asset management

(Kumar et al., 2013). These maintenance strategies utilize mechanisms that can mitigate possible defects and failure. Compared to the corrective maintenance strategy, this advanced process enables managers to eliminate prolonged downtimes by promoting asset capacity and productivity (Kumar et al., 2013). For instance, policies, objectives, and goals are discussed under the basic data section. Assessment of asset condition and necessitated levels of service from rail networks are discussed under the performance metrics. Forecasting and performance modeling coupled with funding assessment comprise the needs analysis section. On the other hand, program optimization and alternative assessment are identified under the program analysis section. The program delivery area constitutes the program creation and implementation actions towards increased asset value and reliability. The standard is designed for rail organizations with significant physical assets to ensure value creation in the long term (Abuzayan et al., 2014; Chen & Bai, 2019).

Increased research on the discussed standards of asset management in this thesis is essential to enable VR Group effectively align stakeholders' ideas of value creation with management goals and objectives aimed to guide the decision-making process. Finnish railway companies such as VR Group are distinguished through higher transparency of managerial data. Such companies efficiently utilize performance information, analytical technologies, and communication channels to facilitate information sharing among internal stakeholders. The ISO 55001 standard outlined the process for developing, reviewing, and updating the policy process of essential railway network routes. The other two standards (ISO 55000 and 55002) supplement ISO 55001 by highlighting the principles and guidelines for its integration. However, this standard cannot be employed to demonstrate financial and technical requirements for asset management since it concentrates on the aspects for a management system (Talan & Sharma, 2019). Most rail companies utilize cost/benefit analysis mechanisms, simulation, database query, risk analysis, and many more methods to assess substitute decisions. Therefore, future research associated with the standards should focus on analytical tools for assisting companies determine the impact of different managerial decisions. In this case, such tools promote sustainable asset management practices aimed towards achieving stakeholder expectations.

Various studies view asset management as the decision-making process of asset safety and care. These areas should be considered by numerous researchers in the future discussion on optimal asset management across physical asset companies. Periodic de-

velopment and improvement facilitate the implementation of business programs for continued optimization of physical assets and enhancement of value and return on investments.

Further, decreased uncertainties in the maintenance process ultimately maximize service provision in the industry. Railway companies integrate routine-centric strategies in terms of periodic intervals, which can be founded on either calendar or operating durations. However, routine maintenance strategies include unprecedented activities which are incapable of enhancing asset availability (Kumar et al., 2013). As a result, over-maintained physical assets increase operational expenses that do not enhance asset usability and functionality. Modern railway companies are encouraged to adopt an integrated and collaborative model to promote performance management across business units. When planning asset activity, railway companies are encouraged to identify possible methods for managing risks during operations (Zuashkiani et al., 2011). In this case, company transition from a silo-based asset management system to a more advanced model requires information transparency, as well as coordination among stakeholders to achieve mutual objectives. ISO 55001 clearly reflects on the risk management guidelines outlined under ISO 31000 (Nielsen et al., 2016). These guidelines are fundamental for VR Group since they define the impacts of uncertainty on company goals and objectives. These uncertainties encompass both opportunities and threats in the rail industry. ISO 55001 applies a systematic approach that facilitates a continuous enhancement and value creation through precise asset-based performance, risk, and expenses. Enhancing production and reliability, minimizing operating expenses, and improving asset effectiveness are some of the major benefits of the standard.

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