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BUILDING TOMORROW'S INFRASTRUCTURE

Digitally Empowered Asset Management for Vision 2030

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Abstract

Saudi Arabia is currently undergoing a monumental transformation, with its infrastructure investments playing a pivotal role in achieving the ambitious goals outlined in Vision 2030. Landmark projects such as NEOM, the Red Sea Development, and Qiddiya are reimagining the Kingdom's infrastructure landscape, positioning Saudi Arabia as a global hub for innovation, sustainability, and economic diversification. As these mega-projects unfold, there is an urgent need for a strategic shift in how assets are managed throughout their lifecycle. Traditional, capital expenditure-focused approaches are no longer sufficient to support the long-term value of these investments.

This thought leadership piece is grounded in an expert discussion with George Galambos, a highly respected civil engineer and asset management consultant with over three decades of global experience. With his extensive credentials, including CAMA2, CSAM, PMP, AMP, and FIAM, George has provided invaluable insights into how Saudi Arabia can modernize its asset management practices. This document explores the critical role of digital technologies, lifecycle management, and global best practices in ensuring the sustainability and efficiency of the Kingdom's infrastructure moving forward.

About MP Perspectives

The MP Perspective Series curates insights from conversations with leading thinkers across Management Partners and MP-Connect's expert network. Rooted in real-world experience and strategic dialogue, the series explores the most pressing themes in economic development, corporate and public strategy, and business and technology transformation. From reimagining institutional roles in rapidly shifting economies to unlocking value through digital innovation and AI, each edition connects the dots between macro trends and actionable insights. Designed for decision-makers and forward-thinkers, the MP Perspective Series provokes new ideas, challenges assumptions, and illuminates pathways toward more resilient and future-ready organizations.

About the Expert

George Galambos is the Director of Galambos Consulting Co., W.L.L., an affiliate of Management Partners through the MP-Connect expert network. With over 25 years of experience, he specializes in strategic asset management systems, focusing on assessing organizations against ISO 55000 standards, evaluating asset condition, risk, and criticality, and developing comprehensive asset management plans. His expertise spans civil engineering, infrastructure design, planning, and project management across the Americas, Africa, and the Middle East.

George holds a Bachelor's degree in Civil Engineering Technology from the University of North Carolina and is highly qualified in asset management. He has earned the Institute of Asset Management's Certificate in Asset Management and Diploma with Distinction. He is a Certified Asset Management Assessor (CAMA2) and Certified Senior Principal in Asset Management (CSAM) with the World Partners in Asset Management (WPiAM). As a Fellow of the IAM and listed on their Register of Asset Management Professionals (AMP), he brings deep technical and strategic knowledge to asset management consulting.

His notable projects include collaborations with Ashghal in Qatar, Haya Water in Oman, and the National Water Company, as well as the Royal Commission for Jubail and Yanbu in Saudi Arabia. George's work focuses on enhancing the performance and sustainability of infrastructure assets through robust asset management systems and practices, enabling organizations to deliver long-term value while effectively managing risks.

Executive Summary

Saudi Arabia is on the cusp of an unprecedented infrastructure transformation as part of its Vision 2030 goals. The Kingdom is investing trillions of riyals into mega-projects like NEOM, the Red Sea Development, Qiddiya, and more, all of which are redefining the nation's infrastructure landscape. These projects are not only about building state-of-the-art cities and expanding infrastructure; they represent a larger vision to propel Saudi Arabia into the future, one that is sustainable, economically diversified, and globally competitive. However, the complexity and scale of these initiatives necessitate a paradigm shift in how infrastructure assets are managed.

Traditionally, asset management in Saudi Arabia was a reactive process, driven by a "run-to-failure" mindset, primarily focusing on capital expenditure (CAPEX). As public projects were mainly funded by the Public Investment Fund (PIF), which had extensive oil revenue available, there was limited consideration for fiscal prudence. As global economic conditions evolve and fiscal resources become less predictable, this approach is no longer sustainable for managing the Kingdom's rapidly expanding and technologically sophisticated infrastructure.

To align with the goals of Vision 2030, Saudi Arabia must adopt a lifecycle-focused asset management strategy. This means shifting from a fragmented, capital-centric model to one that considers the entire lifespan of assets; from planning and design through operations, maintenance, and eventual decommissioning. As George Galambos, a seasoned asset management consultant, emphasized during our expert discussion, asset management must move beyond being a back-office function to a strategic enabler of long-term value.

At the heart of this transformation are modern technologies, including the Internet of Things (IoT), Building Information Modelling (BIM), digital twins, and Artificial Intelligence (AI). These technologies enable real-time monitoring, predictive maintenance, & data-driven decision-making. IoT, for example, allows infrastructure systems to continuously send data regarding their condition, helping to prevent asset failures before they occur. Digital twins create virtual replicas of physical assets, offering valuable insights into their lifecycle and enabling scenario-based simulations to anticipate future performance. Collectively, these technologies turn asset management into a proactive, intelligence-driven discipline that helps maximize value and extend the life of infrastructure.

The integration of such technologies into the asset management ecosystem is crucial for Saudi Arabia to manage its complex infrastructure projects effectively. This requires not just adopting new tools but aligning with global standards and best practices. Standards such as ISO 55000 and guidelines, including the Global Forum on Maintenance and Asset Management's (GFMAM) Asset Management Landscape, and the IAMs 10-Box Capabilities Model, provide strategic frameworks for asset management systems that complement the operational depth of Saudi Arabia's guidelines, such as the Saudi National Manual for Asset and Facilities Management (SNMAFM). While the national frameworks provide a strong foundation, a significant gap remains in their consistent implementation across sectors.

George Galambos rightly pointed out that despite the robust frameworks in place, the implementation remains inconsistent. Fragmented data systems, siloed departments, and outdated practices often prevent the full realization of the potential that digital technologies can offer. For instance, departments managing utilities, transportation, or healthcare each operate in isolation, which not only hinders efficiency but also leads to missed opportunities in optimizing asset performance. Overcoming these challenges

requires a concerted effort to break down silos, align practices across sectors, & adopt a cohesive, integrated asset management approach.

The benefits of embracing an integrated, technology-driven asset management system are manifold. Not only will it reduce operational inefficiencies and maintenance costs, but it will also enhance the long-term resilience and sustainability of Saudi Arabia's infrastructure. For example, predictive maintenance enabled by IoT and AI can drastically reduce the likelihood of service disruptions & extend the life of critical infrastructure. In addition, AI-powered analytics can optimize resource allocation, improve budgeting accuracy, & help prioritize maintenance efforts based on the most critical needs, ultimately ensuring that public services are more reliable & cost-effective.

Yet, technology alone will not drive this transformation. Cultural and institutional readiness are equally crucial. As Saudi Arabia embraces digital asset management, public sector organizations must prioritize upskilling their workforce. Many of the existing workforce members, especially mid-level managers, are accustomed to traditional ways of working and may be resistant to change. Therefore, structured training programs and a shift in mindset are needed to foster long-term planning, cross-functional collaboration, and accountability for data quality. A culture that values continuous learning, embraces new technologies, and focuses on long-term value is essential for overcoming these challenges.

Beyond the workforce, leadership across both the public and private sectors must be aligned on the importance of asset management. The government, in particular, has a central role to play in setting policies that incentivize the adoption of these technologies and ensure that asset management principles are embedded in every phase of infrastructure development, from planning to procurement to operations. By offering funding incentives for the integration of digital tools, such as BIM and digital twins, the government can accelerate the adoption of these technologies and ensure they are utilized to their full potential.

The success of Saudi Arabia's Vision 2030 infrastructure transformation depends on collaboration from key stakeholders across both public and private sectors.

- **Government agencies** should integrate asset management into every stage of infrastructure development, prioritizing lifecycle management from planning to decommissioning. They must create policies that encourage financial innovation and ensure alignment with global standards.
- **Private sector developers and contractors** must embed lifecycle asset management from design through construction, ensuring the transfer of assets with complete, usable data for future management.
- **Asset owners**, both public and private, must extend their role beyond maintenance to long-term stewardship. They should incorporate predictive maintenance and sustainable practices to optimize asset performance and generate additional value.
- **Educational and training institutions** must develop specialized programs to prepare a skilled workforce in lifecycle planning, financial innovation, and advanced asset management practices.

Collaboration among these stakeholders will create a sustainable and efficient asset management ecosystem to achieve Vision 2030 goals. The road ahead requires clear action, thoughtful strategy, and the involvement of all sectors to build a resilient infrastructure ecosystem.

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1. The Strategic Imperative: Redefining Value in a Trillion-Riyal Transformation

1.1 Historical context: A shift from sunk cost to Strategic Asset Management

Saudi Arabia stands at the precipice of an unprecedented infrastructure transformation, driven by the ambitious Vision 2030 initiative. The country is making some of the most significant infrastructure investments in the world, with landmark projects such as NEOM, the Red Sea Project, Qiddiya, and New Murabba leading the charge. These mega-projects are not just about building new cities or expanding infrastructure; they are about redefining what infrastructure means in the context of a modern, tech-enabled nation. However, the very scale of these investments creates a pressing need for a fundamental shift in how Saudi Arabia approaches asset management.

Traditionally, asset management in the country operated on a "run-to-failure" model, an approach that was supported by the surpluses generated by high oil prices. When infrastructure failed, resources were readily available to replace it. However, as global economic

conditions evolve and fiscal pressures mount, it is no longer viable to depend on such a reactive model.

"The scale and complexity of these projects, such as NEOM and the Red Sea Development, demand a more robust, lifecycle-based asset management approach. These investments are too significant to let them become liabilities due to poor management."

This strategic shift is not just about managing assets more effectively, but also about preserving the long-term value generated by these multi-billion-dollar investments.

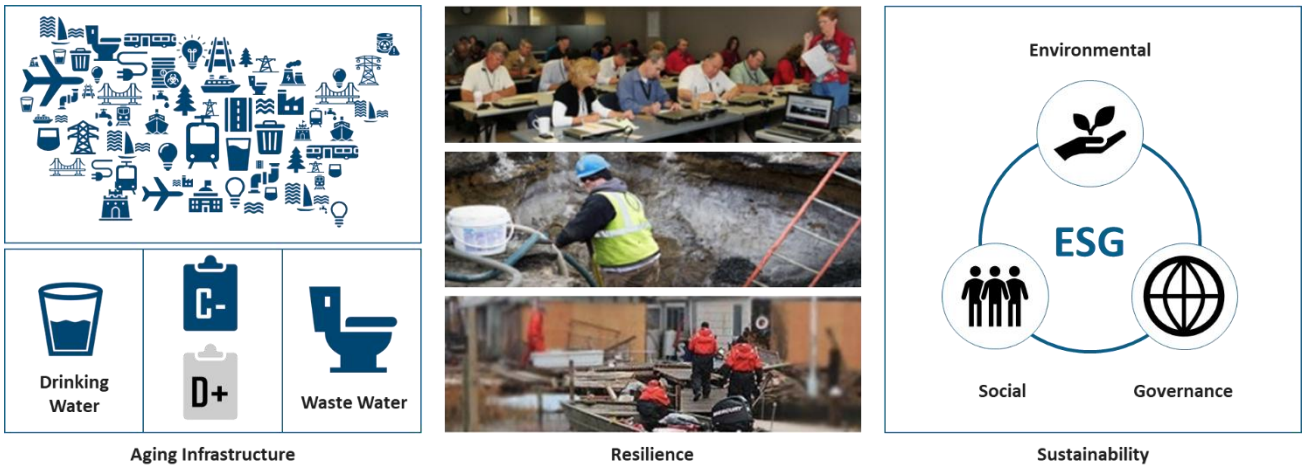


Exhibit 1: Asset Management – Why is it Important & Why Now[1]

To make Vision 2030 a success, Saudi Arabia needs to adopt a lifecycle management approach that goes beyond the traditional capital expenditure (CAPEX) mindset. It is crucial to recognize that the value of infrastructure extends not only to its construction but also to its ongoing operation, maintenance, and eventual decommissioning. Failing to do so would result in value leakage, where the costs of maintaining and operating assets outweigh their benefits, potentially jeopardizing the national goals of sustainability, efficiency, and economic diversification.

Exhibit 1 highlights factors such as aging infrastructure, resilience, and sustainability; underscore the need for a more structured approach to managing assets, moving beyond the traditional "run-to-failure" model that was prevalent in Saudi Arabia due to ample oil revenue. As the country scales up its infrastructure projects, there is an increasing demand for a lifecycle-based asset management strategy that ensures long-term value retention and operational efficiency. The focus on resilience and sustainability underscores the importance of viewing assets not as immediate sunk costs but as long-term investments that necessitate careful planning, maintenance, and optimization to prevent costly failures and ensure economic sustainability in line with Vision 2030.

1.2 The Financial and Operational Risks: Fragmented Asset Management

As Saudi Arabia embarks on its large-scale infrastructure transformation, continuing with fragmented and outdated asset management practices presents significant financial and operational risks. Traditionally, asset management has focused primarily on upfront capital expenditures (CAPEX) without considering the long-term costs associated with operations, maintenance, and lifecycle management. This approach creates several vulnerabilities for large, complex infrastructure projects.

When asset management systems are not integrated or aligned across sectors, it leads to inefficiencies, including inconsistent data, duplication of efforts, and poorly coordinated maintenance schedules. These operational inefficiencies result in increased maintenance costs, more frequent failures, and service disruptions that can have far-reaching economic consequences.

"Traditional approaches focus on upfront capital delivery, often overlooking lifecycle costs, maintainability, or operational resilience. This typically leads to higher total costs, frequent failures, and service disruptions."

Additionally, without a unified approach, there is a tendency to operate in silos, with different departments or organizations managing their assets independently. This lack of coordination often results in missed opportunities for optimizing asset performance, underutilized assets, and budget overruns. Fragmented asset management also makes it more challenging to adopt advanced technologies, such as IoT and digital twins, which require consistent data and system integration to deliver their full value.

For Saudi Arabia, the opportunity cost of maintaining such fragmented practices is enormous. As Vision 2030 calls for smart, sustainable cities and infrastructure, continuing with a reactive, CAPEX-driven model will undermine the Kingdom's efforts to maximize the value of its infrastructure investments. Transitioning to a lifecycle-focused, integrated asset management strategy is crucial to mitigating these risks and achieving long-term operational efficiency, cost savings, and improved public services.

By adopting an integrated asset management approach that spans the entire lifecycle, from planning and procurement to operations and maintenance; Saudi Arabia can minimize risks,

reduce inefficiencies, and ensure that infrastructure investments deliver long-term value.

1.3 Technological Transition: From Reactive to Predictive Asset Management

The role of technology in this transformation cannot be overstated. As Saudi Arabia embraces more modern forms of infrastructure, characterized by digital, mechanical, and electrical systems; it faces new challenges. These challenges range from integrating advanced technologies into existing infrastructures to ensuring that new projects are equipped to leverage the full potential of digital innovations.

Technologies such as IoT, digital twins, and advanced analytics are not just enabling better asset management; they are fundamentally changing the expectations surrounding asset owners and operators. Traditionally, asset management has been reactive, often addressing problems only after they have occurred. Now, however, with the advent of IoT and digital twins, it is increasingly possible to monitor the condition of assets in real-time, predict failures before they happen, and proactively address issues before they lead to costly repairs.

"IoT and digital twins have shifted asset management from a reactive task to a proactive, intelligence-driven discipline. IoT enables real-time condition monitoring, helping us prevent failures and extend asset life. Digital twins allow simulation and lifecycle scenario planning, transforming how we design and operate assets."

For instance, IoT sensors can monitor everything from pressure to temperature to vibration, providing continuous, real-time data that human operators could not possibly observe. Digital twins provide a digital replica of physical assets, enabling scenario-based simulations that predict potential outcomes based on real-time data. These innovations enable more intelligent decision-making and more effective asset management.

The shift from reactive fixes to predictive maintenance also helps optimize operational performance. Real-time data and insights empower asset owners to make informed decisions, ultimately leading to more effective resource allocation and cost-saving measures. As such, digital technologies are not just adding efficiency to operations but are fundamentally reshaping the asset management landscape, enhancing the value derived from every riyal invested in infrastructure.

1.4 Opportunity Costs: The Consequences of Not Integrating Lifecycle Thinking

Neglecting lifecycle thinking during the early stages of infrastructure projects can result in significant opportunity costs, particularly as Saudi Arabia undertakes its large-scale infrastructure transformation under Vision 2030. These costs stem from poor design decisions that, once made, are difficult, if not impossible, to reverse. Failing to integrate lifecycle planning from the outset locks in inefficiencies, often leading to increased costs and operational challenges over time. As George Galambos highlights,

"When lifecycle thinking is left out early on, poor design decisions get locked in, like oversized systems or inaccessible components, that are expensive or impossible to fix later."

One of the most common pitfalls of neglecting lifecycle planning is designing oversized or inefficient systems. For example, in projects as ambitious as NEOM, where innovative technologies and large-scale systems are central to the development, failing to plan for future operational needs can lead to overdesigning infrastructure. Oversized systems, although capable of handling short-term demand, often lead to

inefficiencies in energy consumption, resource utilization, and maintenance. These inefficiencies create ongoing operational costs that could have been avoided with a more thoughtful, lifecycle-based design approach.

Another critical impact of failing to integrate lifecycle thinking is the inability to account for environmental and operational challenges that may arise as the infrastructure is put into use. Saudi Arabia's harsh climate, characterized by extreme temperatures and high humidity, presents unique challenges that must be considered during the design phase. Without lifecycle planning, systems and materials may degrade prematurely, leading to unanticipated costs for retrofits or replacements. This could result in infrastructure that is not resilient enough to meet the Kingdom's long-term needs.

The financial consequences of ignoring lifecycle thinking can also be substantial. The lack of a lifecycle approach typically leads to reactive maintenance strategies, which are far more expensive than proactive, data-driven asset management.

"The result is higher operating costs, premature asset failures, and costly retrofits."

These higher costs put a strain on both public and private sector budgets, diverting resources that could be better spent on future projects or enhancing service delivery.

Finally, neglecting lifecycle planning prevents Saudi Arabia from fully leveraging the potential of digital technologies, such as IoT, AI, and digital twins. These technologies enable real-time monitoring, predictive maintenance, and long-term scenario planning; critical elements in optimizing asset performance and extending their lifecycles. By embedding lifecycle thinking early in the design and procurement stages, Saudi Arabia can ensure that infrastructure is more efficient, resilient, and aligned with the nation's sustainability goals under Vision 2030. This will ultimately create long-term value for the Kingdom's citizens and businesses, aligning infrastructure investments with the broader strategic objectives of economic diversification and sustainability.

2. From Infrastructure to Intelligence: Asset Management as a Vision 2030 Enabler

2.1 Direct Contribution to Vision 2030: Enhancing Reliability and Service Delivery

Asset management is a cornerstone of Saudi Arabia's Vision 2030, serving as a crucial enabler in the nation's infrastructure transformation. As the country ramps up investments in sectors like healthcare, transportation, utilities, and urban development, efficient and sustainable asset management becomes integral to delivering on the Vision's promises. The ability to manage assets throughout their entire lifecycle, from planning and construction to operation, maintenance, and eventual decommissioning; ensures that public services are not only reliable but also sustainable in the long term.

"Asset management directly supports Vision 2030 by making infrastructure more reliable, cost-effective, and sustainable. In healthcare, asset management ensures that critical equipment and facilities remain available. In transportation networks, it keeps them safe and efficient, and in cities, it ensures high service quality through predictive maintenance."

This approach not only addresses the immediate needs of the population but also strengthens fiscal discipline, aligning assets with the long-term needs of Saudi citizens. For instance, in healthcare, where the availability of critical medical equipment can mean the difference between life and death, asset management ensures that resources are allocated effectively, leading to improved service delivery. In transportation networks, a proactive asset management strategy helps to reduce downtime, ensure safety, and lower maintenance costs. Urban development projects benefit from asset management through improved liability & enhanced citizen satisfaction, as predictive maintenance minimizes service disruptions.

As illustrated in Exhibit 2, the number of academic publications on enabling technologies, such as IoT, Big Data, Machine Learning, and Digital Twins, in the context of predictive maintenance has increased significantly since 2015, reflecting the growing global shift towards data-driven, proactive asset management strategies.

Moreover, asset management in Saudi Arabia is evolving from a traditional reactive approach to a more advanced, predictive model. With the integration of technologies like IoT and digital twins, asset owners and operators can now anticipate potential failures and address them before they cause significant disruptions. This shift towards predictive management not only enhances the efficiency of asset utilization but also aligns with national objectives to ensure sustainable, cost-effective infrastructure. In line with Vision 2030, this predictive approach enhances both the reliability and the cost-efficiency of critical infrastructure services.

The impact of strategic asset management is far-reaching, particularly when applied across sectors that directly influence the quality of life for citizens. From maintaining essential services like water and energy to ensuring the functionality of public transport and healthcare systems, effective asset management acts as a lever for achieving Vision 2030's goals of economic Diversification, Sustainability, and enhanced public services

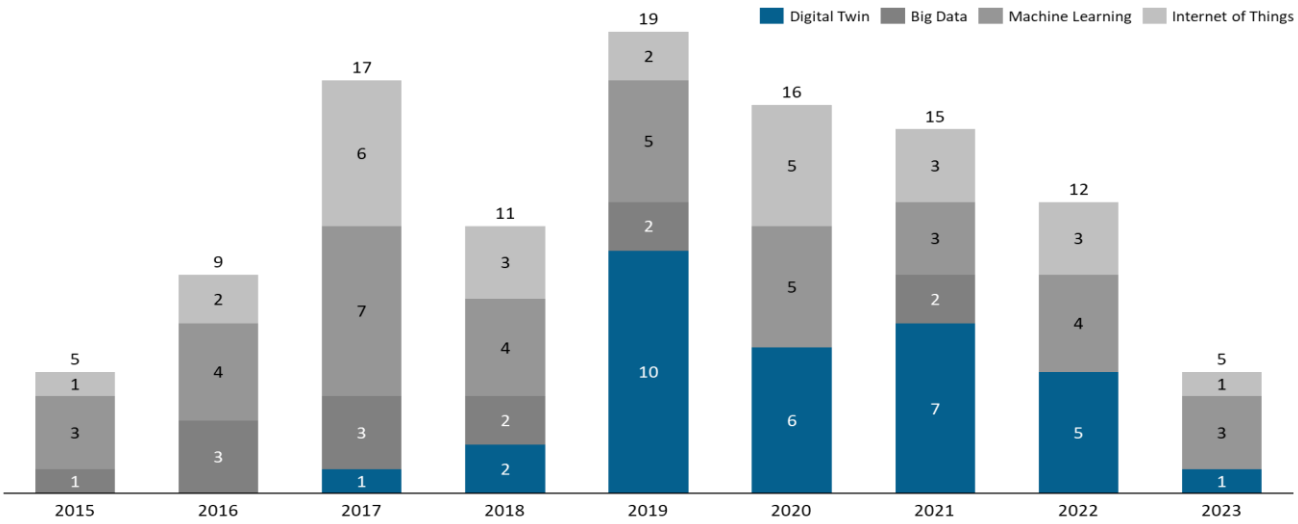


Exhibit 2: Trend of enabling technologies in Predictive Maintenance (2015-2023); Number of Papers[2]

2.2 Leveraging Advanced Technologies: AI and Advanced Analytics for Smarter Decision-Making

To fully realize the benefits of asset management and its role in achieving Vision 2030, Saudi Arabia must harness the power of advanced technologies, including artificial intelligence (AI), machine learning, and data analytics. These technologies enable asset managers to make informed, data-driven decisions that optimize the performance of infrastructure assets while minimizing costs and risks.

"AI helps detect patterns, predict failures, and support automated decision-making. This improves transparency and helps manage risk. Analytics provide benchmarking and highlight inefficiencies, supporting scenario-based planning."

The ability of AI to predict when assets are likely to fail, for instance, enables asset managers to take pre-emptive action, scheduling maintenance before failure occurs, which can significantly reduce costs associated with reactive repairs.

Advanced analytics also enhances governance by providing real-time insights into asset performance, enabling transparent and informed decision-making. With AI-powered systems, asset managers can analyse historical and real-time data to create predictive models, which support the prioritization of maintenance activities and resource allocation. This leads to improved service delivery and greater cost efficiency, aligning with Vision 2030's emphasis on enhancing fiscal management and ensuring sustainable infrastructure.

The use of analytics also supports scenario-based planning, which is essential for managing the complexities of large-scale infrastructure projects. By simulating various maintenance and operational scenarios, decision-makers can gain a deeper understanding of potential outcomes, optimize asset lifecycles, and plan more effectively for future demands. This level of data-driven foresight enables the Saudi government to manage public assets more efficiently, directly contributing to Vision 2030's objectives of enhancing quality of life, promoting economic growth, and promoting sustainability.

2.3 Smart Cities: Models for Asset-Intelligent Development

Saudi Arabia's smart city initiative offers a prime example of how asset management, when combined with digital technologies, can deliver on the objectives of Vision 2030. By integrating physical and digital infrastructures, smart cities not only enhance the efficiency of public services but also demonstrate how strategic asset management can be effectively integrated into the urban design and planning phases.

One of the key partners in this initiative is Naver. This South Korean technology company has played a crucial role in creating highly detailed digital models of specific areas in Saudi cities.

"In Saudi Arabia, there's an initiative for digital twins. There is a partner, Naver from South Korea, that has built digital models of specific parts of certain cities with a precision of down to 10 centimetres. So those models are being used and deployed and used to make infrastructure decisions like conflict detection."

These digital twin models are transformative in their ability to provide real-time data and simulation capabilities that inform critical infrastructure decisions. They help urban planners and asset managers understand the complexities of urban systems, such as traffic flow, energy consumption, and water distribution, enabling them to optimize resource allocation and ensure the sustainability of services. The use of digital twins in Saudi Arabia's smart cities ensures that assets are efficiently managed from the very start, with an integrated approach that combines physical and digital components.

Additionally, these models are invaluable for conflict detection and prevention, particularly in areas like infrastructure development, where new projects may intersect with existing utilities or systems. By having precise, up-to-date digital models of the city, potential issues can be detected and resolved before construction begins, saving time and money while avoiding costly disruptions.

These smart city models, powered by advanced digital technologies, not only optimize the management of urban assets but also serve as scalable examples for other regions of Saudi Arabia. The integration of asset management into the early design and planning phases of urban development ensures that Saudi cities can grow sustainably and efficiently, directly contributing to Vision 2030's broader goals.

2.4 Real-World ROI: Examples of Digital Asset Management Improving Citizen Outcomes

The integration of digital asset management technologies has already begun to show real-world benefits in various parts of the world. For instance, IoT-based condition monitoring has proven effective in reducing outages and extending the life of public utility assets.

"IoT-based condition monitoring has helped reduce outages and extend asset life in public utilities, directly improving ROI. For example, the U.S., Netherlands, and Arabian Gulf utilities use inline pressure sensors and SCADA feedback to manage pressure surges and reduce pipe failures."

By incorporating IoT sensors into critical infrastructure, these regions have been able to predict when assets will fail and proactively address issues before they lead to service disruptions. In Saudi Arabia, this technology could have a similar impact on public utilities, reducing water and energy losses, preventing costly repairs, and improving the overall reliability of services.

In transportation, digital asset management has proven instrumental in ensuring safety and reducing lifecycle costs. Countries such as Australia, the UK, and the UAE have utilized

technologies like Light Detection and Ranging (LIDAR) and Geographic Information System (GIS) to monitor the condition of pavements and roads, enabling predictive maintenance that reduces the risk of accidents and service disruptions. This not only improves the safety of transportation networks but also reduces the long-term costs associated with road repairs and closures.

For Saudi Arabia, leveraging these technologies in public infrastructure projects will directly benefit citizens. By ensuring that assets are properly maintained, failures are prevented, and services are delivered efficiently, the Kingdom can significantly enhance the quality of life for its population. This is a tangible outcome that aligns with Vision 2030's commitment to improving service delivery and public welfare.

3. Closing the Gap: Confronting Implementation Challenges Head-On

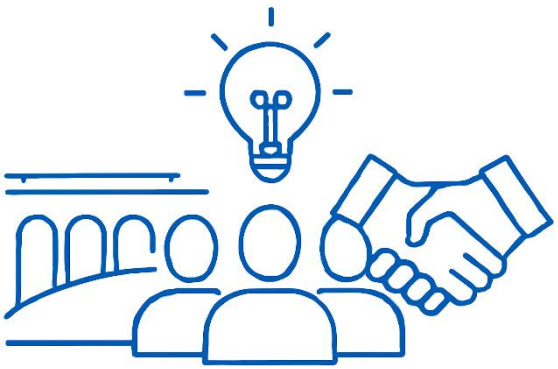
3.1 Implementation Inconsistencies: A Call for Holistic Adoption

While Saudi Arabia's National Manual for Asset and Facilities Management (SNMAFM) and the Ministry of Finance's Valuation Guide provide a strong foundation for asset management, their implementation across various sectors has been inconsistent. Some sectors are making significant progress, aided by external consultants and digitally-savvy teams, while others are lagging due to challenges in enforcement, fragmented governance, and varying levels of technical expertise.

"The frameworks are strong, but their implementation is inconsistent across sectors. Some sectors are doing well, but others face challenges in enforcement and system integration."

The reality is that these frameworks, although essential, will not reach their full potential without widespread and uniform adoption across all sectors. This lack of consistency results in inefficiencies that hinder the effectiveness of asset management in driving value from infrastructure projects. To bridge this gap, Saudi Arabia must create an environment where these frameworks are not only adopted but are seamlessly integrated into daily operations across all sectors.

The challenge lies not only in adopting asset management practices but also in fully integrating them into the fabric of infrastructure planning, development, and operations. The inconsistency in implementation means that sectors such as utilities, transportation, and healthcare may not be fully leveraging the potential of asset management practices, resulting in missed opportunities to optimize resources, reduce costs, and extend asset lifecycles.



The solution lies in creating an institutional culture that prioritizes the adoption of asset management principles across all levels of the organization. From government ministries to private sector partners, every stakeholder must align with the national vision of asset management, ensuring a unified approach that integrates risk management, lifecycle planning, and performance optimization.

3.2 Cultural Resistance: Overcoming Institutional Inertia

One of the most significant barriers to successful asset management implementation is the cultural resistance found in many organizations. In Saudi Arabia, as in many other parts of the world, asset management has traditionally been seen as a back-office function, a necessary but often overlooked aspect of infrastructure operations. This perception can lead to a reluctance to embrace change, particularly when it involves the introduction of new technologies and processes.

"Many organizations are hierarchical, and mid-level managers are often reluctant to take direction from younger employees who are more digitally literate. Bridging this generational gap requires fostering a culture that supports long-term planning and data-driven decision-making."

This generational gap in knowledge and approach can be a significant impediment to

progress. Older employees who are accustomed to traditional methods may resist the shift to data-driven, technology-enabled asset management. In contrast, younger, tech-savvy employees may feel frustrated by the slow pace of change.

Overcoming this cultural resistance will require a comprehensive change management strategy that includes leadership buy-in, cross-generational collaboration, and targeted education programs. Leaders must recognize that embracing asset management as a strategic function, rather than a technical back-office operation, is essential to achieving Vision 2030's broader goals of sustainability, economic diversification, and citizen satisfaction.

Instituting structured training programs that cover both the fundamentals of asset management and the integration of digital tools will help employees at all levels develop the skills needed to transition to a more forward-thinking approach. Additionally, fostering a culture that supports innovation, experimentation, and long-term planning will help create a more agile and adaptive workforce that is better equipped to navigate the challenges of the digital age.

3.3 Data Fragmentation and Skill Shortages: Building the Foundation for Success

Another significant hurdle to the effective implementation of asset management is data fragmentation. Many public sector organizations in Saudi Arabia still operate with siloed data systems, where information is stored in isolated departments or platforms, making it challenging to create a comprehensive, unified view of asset performance. This fragmentation leads to inefficiencies, delays in decision-making, and missed opportunities for optimization.

"Common barriers include siloed data, inconsistent specifications, change resistance, and skill shortages. Often, systems like CMMS or BIM are treated as isolated tools instead of being part of an integrated ecosystem."

When data is not shared across systems and departments, it becomes challenging to maintain accurate, up-to-date records of asset performance, lifecycle status, and maintenance requirements. This not only reduces the effectiveness of asset management tools but also impedes real-time decision-making, as managers lack the necessary information to make informed, data-driven choices.

To overcome this challenge, Saudi Arabia must prioritize the development of integrated data systems that can consolidate information from across sectors. A unified asset management system will enable real-time tracking of asset performance, predictive maintenance scheduling, and better alignment with national infrastructure goals. Furthermore, the integration of technologies like IoT, digital twins, and AI into asset management frameworks will provide the real-time insights necessary to optimize operations and extend asset lifecycles.

Alongside data integration, there is also a pressing need for skill development. The introduction of digital tools and technologies in asset management requires a new set of competencies. Saudi Arabia's public sector organizations must invest in upskilling their workforce to handle the complexities of modern asset management. This includes training in data governance, digital tools such as BIM and CMMS, as well as advanced analytics.

"KSA organizations need to develop an AM-centric culture that supports long-term planning, cross-functional collaboration, and accountability for data quality."

Building a robust skill base will not only enhance the effectiveness of asset management but also enable Saudi Arabia to develop a workforce capable of driving the digital transformation necessary to achieve Vision 2030.

3.4 Capability Building: Training and Leadership for Successful Implementation

Closing the implementation gap requires more than just technological advancements; it requires a fundamental shift in organizational mindset and capability. As asset management practices evolve, so too must the skills and knowledge of the workforce. The rapid development of digital technologies, such as AI, IoT, and digital twins, has made traditional approaches to asset management obsolete, underscoring the importance of continuous learning & upskilling.

To address this need, Saudi Arabia must focus on creating a national framework for asset management training. Professional organizations, such as the Institute of Asset Management (IAM), which has branches in KSA and UEA, and the Gulf Society for Maintenance and Reliability (GSMR), based in Manama, Bahrain, offer certification programs and peer learning opportunities that can be utilized to build a more knowledgeable and skilled workforce.

"There are a lot of young Saudis coming out of the university system with degrees in data and analytics. By equipping them with the right training and integrating them into asset management functions, we can harness the power of these emerging technologies."

However, training is only one part of equation. Leadership buy-in is essential to ensure that asset management is viewed as a strategic function rather than technical back-office operation.

As shown in Exhibit 3, the Industry 5.0 framework for predictive maintenance emphasizes a layered integration of data acquisition, analytics, human-machine interfaces, and optimization feedback, highlighting the multifaceted capabilities required for successful implementation of modern asset management systems.

Leaders must champion the adoption of asset management principles and digital technologies, ensuring that they are integrated into every stage of infrastructure development, from planning to procurement to operations.

By fostering a culture of cross-functional collaboration and ensuring that leaders are equipped with the knowledge to make informed decisions, Saudi Arabia can close the implementation gap and create a more efficient, sustainable, and data-driven asset management system.

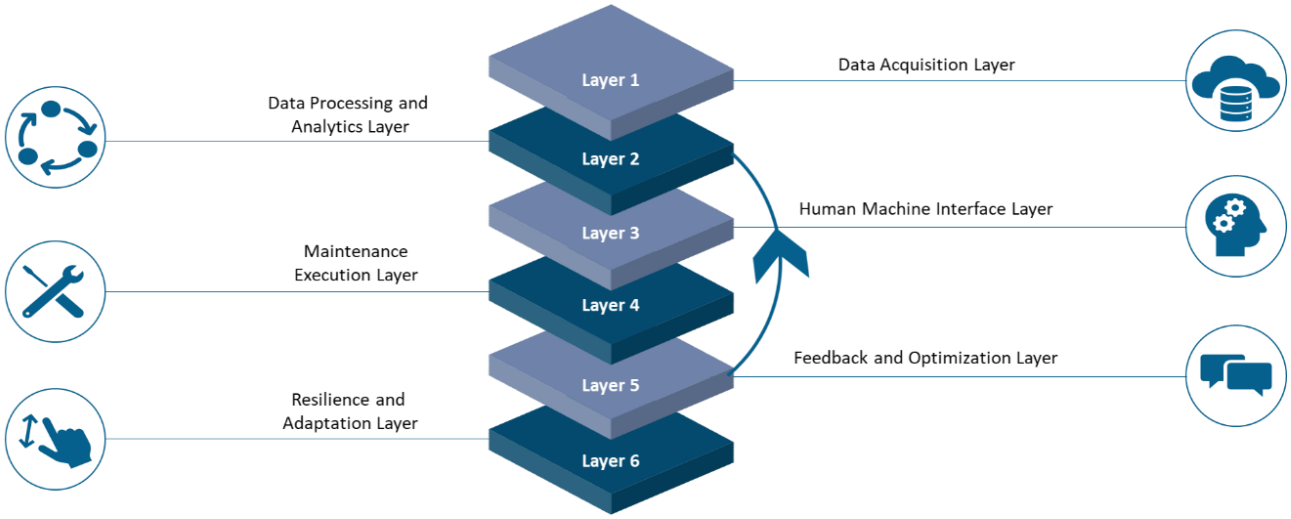


Exhibit 3: Industry 5.0 framework for Predictive Maintenance and Condition Monitoring[3]

4. Institutionalizing the Future: Building a Digitally Enabled, Standards-Aligned Ecosystem

4.1 Aligning with Global Standards: Bridging Local and International Practices

For Saudi Arabia's asset management strategy to reach its full potential, it must integrate international best practices with the country's national standards. Global standards, particularly ISO 55000, provide a comprehensive framework for managing the entire lifecycle of assets, including risk management, value creation, and performance optimization. These standards have been developed through decades of global experience and are widely regarded as best practice in asset management.

"ISO 55000 offers a strategic framework that complements SNMAFM's more detailed operational guidance. It helps bridge national goals and local delivery through planning, governance, and performance monitoring."

While Saudi Arabia's SNMAFM offers more operational depth and a localized approach tailored to the Kingdom's unique needs, integrating it with ISO 55001's strategic framework would create a robust asset management ecosystem capable of driving performance and ensuring sustainability.

The process of aligning these standards is not simply about compliance; it is about leveraging the strengths of both systems to create a unified, technology-enabled approach to asset management. By harmonizing international and national frameworks, Saudi Arabia can achieve the dual goals of aligning with global best practices while meeting its specific development and governance needs. This alignment enables the country to adopt industry-leading asset management practices while addressing local complexities, including environmental conditions, regulatory requirements, and infrastructure demands.

As illustrated in Exhibit 4, the IAM's 10-box Capabilities Model provides a holistic view of asset management that aligns closely with ISO 55001 by encompassing key elements such as strategy, governance, risk management, and continual improvement, thereby offering a clear structure for Saudi Arabia to bridge national practices with global standards.

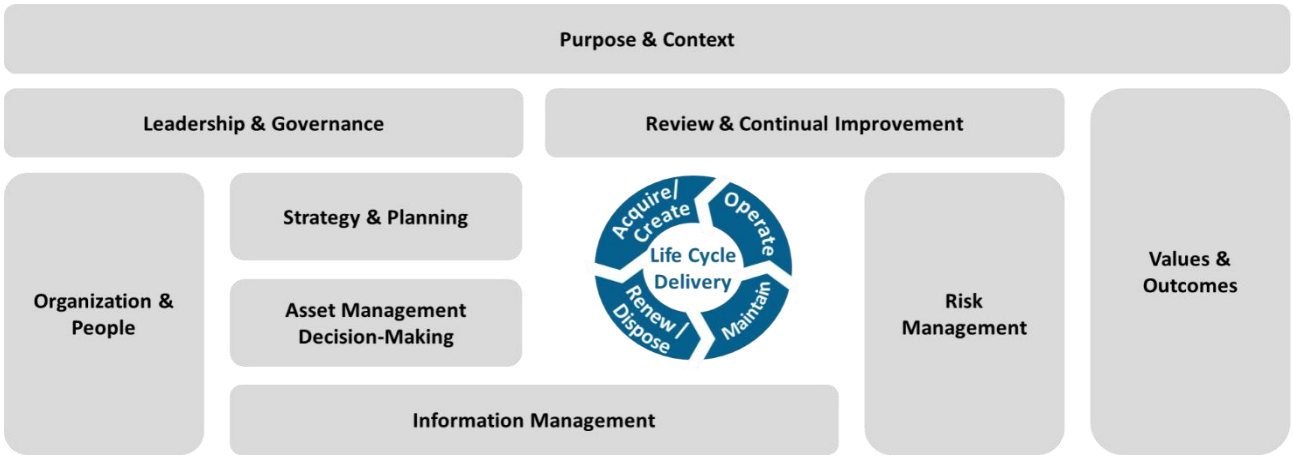


Exhibit 4: The IAM's 10-box Capabilities Model[4]

Furthermore, aligning with ISO 55000 provides a clear path for Saudi Arabia to integrate internationally recognized asset management principles into its regulatory environment, ensuring transparency, accountability, and optimized performance. The use of these global standards will also enhance the Kingdom's ability to attract international investment, as foreign investors often look for markets with established and trusted governance frameworks.

4.2 Leveraging Digital Tools: The Role of Technology in Operationalizing Standards

The integration of digital technologies plays a pivotal role in operationalizing both ISO 55000 and the SNMAFM standards. Tools like Building Information Modelling (BIM), digital twins, and Computerized Maintenance Management Systems (CMMS) are transforming asset management from a manual, time-consuming process to an automated, data-driven function that can optimize asset performance in real-time.

"BIM ensures reliable asset data, CMMS ensures the work gets done, & digital twins provide real-time insights that are critical for maintaining & optimizing assets throughout their lifecycle."

BIM provides an accurate, up-to-date digital representation of physical assets, allowing for better planning and more efficient management from design through to operation. This digital data can be seamlessly integrated into CMMS systems, which track maintenance schedules, performance, and condition across the asset's lifecycle. Meanwhile, digital twins replicate assets in real-time, offering an invaluable tool for simulation and predictive analytics, ensuring that asset managers can make decisions based on current, reliable data.

The ability to manage assets digitally allows for smarter, more strategic decision-making. By aligning digital tools with asset management frameworks, Saudi Arabia can ensure that its infrastructure is managed proactively, with real-time monitoring and predictive capabilities that reduce downtime and extend asset lifecycles. Additionally, the integration of technologies such as IoT sensors, AI, and machine learning enables continuous data collection and analysis, driving more innovative budgeting, risk management, and prioritization of maintenance.

By integrating these technologies into its operational framework, Saudi Arabia can optimize the value derived from every asset, ensuring that public resources are utilized efficiently and effectively and that infrastructure continues to meet the needs of its citizens. The combination of standards and digital tools represents the future of asset management in Saudi Arabia, enabling the country to transition from reactive, manual processes to a dynamic, technology-enabled approach that drives long-term value.

4.3 Learning from Global Models: Adapting Best Practices to the Saudi Context

While Saudi Arabia is making significant strides in asset management, it can learn valuable lessons from global models where technology has already enabled the successful implementation of ISO 55000 standards. Countries like Australia and the UK have long embraced asset management systems that align with PAS 55 (a legacy standard predating ISO 55000) and ISO 55000, utilizing digital technologies to manage lifecycle costs, performance, and risks. These countries offer successful case studies of how asset management frameworks can be scaled and adapted to large infrastructure portfolios.

"Utilities and transport agencies in Australia and the UK's Highways England have used ISO 55000-aligned asset management systems to manage lifecycle costs and performance. Saudi Arabia can learn from their approach to integrated governance, outcome-based procurement, and workforce capability."

In Australia, asset management systems are implemented across utilities and transportation networks, where real-time data and predictive analytics drive optimized performance and cost reductions. Similarly, Highways England in the UK uses ISO-aligned platforms to monitor road asset performance, manage lifecycle costs, and ensure that infrastructure is efficiently maintained over its operational life.

These global models provide clear examples of how asset management can be integrated with national governance frameworks and managed efficiently through technology. By leveraging these case studies, Saudi Arabia can expedite its adoption of asset management best practices and avoid common pitfalls such as data fragmentation, siloed systems, and inefficiencies.

Moreover, these global models highlight the importance of establishing clear governance structures and outcome-based procurement processes. In Australia, for example, asset management systems are often tied to performance benchmarks that ensure infrastructure is both cost-effective and aligned with national priorities. Similarly, in the UK, Highways England has implemented asset management strategies that optimize performance while reducing costs through data-driven decision-making.

By adapting these models to the Saudi context, which includes local environmental factors, regulatory requirements, and infrastructure demands, Saudi Arabia can build a more effective and integrated asset management system. This would enable the country to strike a balance between global best practices and local innovation, ensuring that infrastructure investments not only meet Vision 2030's goals but also deliver long-term value to Saudi citizens.

4.4 Enabling Transformation: Strategic Government Leadership

As Saudi Arabia seeks to modernize its infrastructure under Vision 2030, the government's role in enabling technology-driven asset management cannot be overstated. A forward-looking government strategy is crucial for driving the adoption of asset management best practices, ensuring that infrastructure projects not only meet short-term demands but also deliver long-term value. With a growing focus on sustainability and efficiency, the government must provide the leadership necessary to align policy, regulatory frameworks, and funding mechanisms with the evolving needs of the Kingdom's infrastructure.

To institutionalize asset management as a core discipline, the government must create a clear regulatory environment that aligns with both local and international standards. Incorporating global frameworks, such as ISO 55000, alongside Saudi Arabia's SNMAFM, will enable a comprehensive and unified approach to asset management. By bridging the gap between international best practices and local requirements, the government ensures consistency in infrastructure management, creating a more integrated and resilient asset management system. This alignment supports the long-term goals of Vision 2030 by reinforcing governance and operational resilience, two core pillars of sustainable infrastructure development.

In tandem with aligning standards, the government must foster an environment that supports the integration of emerging technologies. Digital tools, including IoT sensors, AI analytics, and digital twins, are revolutionizing the management of assets throughout their lifecycle. By enabling real-time monitoring and predictive analytics, these technologies provide deeper insights into

asset performance, facilitating proactive decision-making. The government's role in incentivizing the integration of these technologies, particularly through regulatory frameworks and policy support, is critical to ensuring that digital asset management becomes the norm rather than the exception.

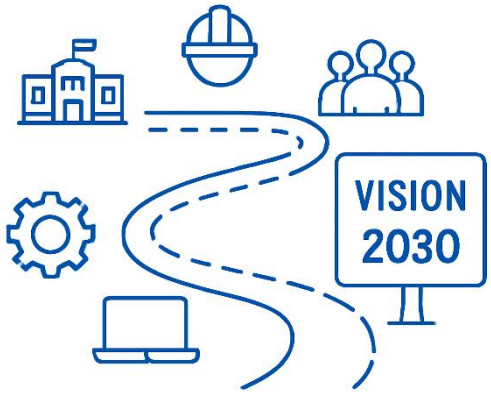
Moreover, the government must promote data interoperability across all sectors. The siloed data approach prevalent in many organizations hinders the full potential of digital tools, preventing the optimal realization of asset management technologies. A national strategy that prioritizes data sharing, integration, and standardization will enable greater collaboration across industries, making the Kingdom's infrastructure more intelligent and more adaptable.

"Public-private partnerships can also help by piloting innovations and rewarding performance outcomes, not just compliance."

The government should continue to encourage public-private partnerships (PPPs), which play a crucial role in accelerating the adoption of innovative asset management solutions. By supporting pilot projects and funding collaborations between public institutions and private companies, the government can test and validate new technologies that have the potential to transform the sector. These partnerships help reduce implementation risks, demonstrate the effectiveness of new solutions, and ultimately build a foundation for broader adoption across the Kingdom.

5. The Path Forward: A Vision for Technology-Driven Institutionalization

For Saudi Arabia to fully realize the potential of its infrastructure investments and align with Vision 2030, asset management must not be treated as an afterthought but as a core discipline embedded from the very beginning of every infrastructure project. This means that asset management must be integrated into the capital planning and procurement processes, starting at the business case stage. Early integration ensures that all assets are designed with their entire lifecycle in mind, from construction and operation to maintenance and eventual decommissioning.



As shown in Exhibit 5, effective asset management must be understood as part of a broader organizational effort, moving from the specific management of asset portfolios through structured asset management systems, and ultimately aligning with the organization's overarching strategic goals.

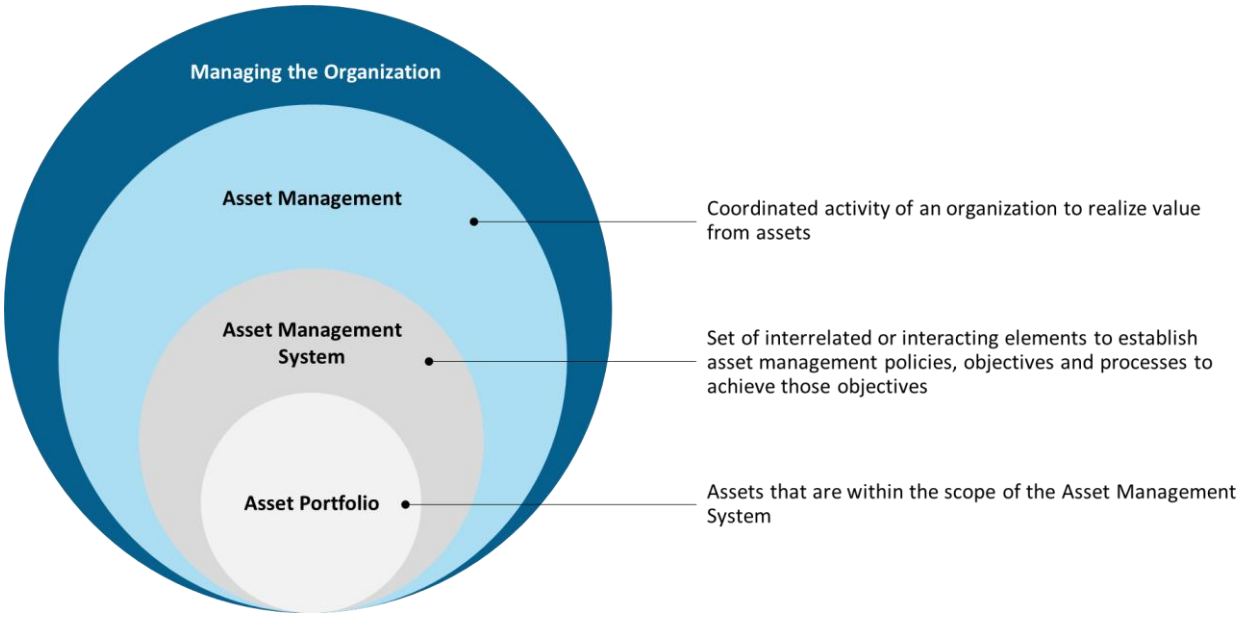


Exhibit 5: Relationship between Asset Management and other entities ('Onion Diagram')[5]

5.1 Embedding Asset Management into Capital Planning: A Critical First Step

Asset management in Saudi Arabia must shift toward a lifecycle-focused approach that emphasizes long-term value creation, striking a balance between operational expenditures (OPEX) and capital expenditures (CAPEX). Historically, asset management has been heavily focused on the initial capital investment phase, with less attention given to the operational and lifecycle costs. As Saudi Arabia embarks on its large-scale infrastructure projects, it is essential to focus on managing assets across their entire lifecycle to ensure sustainable value retention.

The key to effective asset management lies in recognizing that infrastructure is not just about building it; it's about managing it efficiently over its operational life. The long-term costs, including maintenance, repairs, and eventual decommissioning, can often surpass the initial construction costs if not adequately managed. Failing to address lifecycle costs early on leads to value leakage and missed opportunities for optimization.

Public-private partnerships (PPPs) provide a model for commercializing infrastructure assets, transforming them into revenue-generating entities. This approach aligns with the broader trend where infrastructure assets are not just physical constructs but valuable financial instruments that can be monetized through innovative economic strategies.

Key Actions:

- **Focus on Lifecycle Costing**: Shift asset management practices to prioritize the long-term costs of operations and maintenance, rather than focusing solely on construction.
- **Leverage Asset Value**: Explore opportunities for monetizing assets through PPPs and other revenue-generating mechanisms.
- **Enhance Financial Strategy**: Treat assets as long-term investments, incorporating them into broader financial strategies that align with Vision 2030's goals.

5.2 Collaboration Across Sectors: Aligning Asset Owners, Developers, and Operators

The role of asset owners, whether public or private, is evolving. Asset ownership extends beyond maintenance to encompass the long-term strategic management of the asset throughout its entire lifecycle. Asset owners are responsible for design, maximizing the value of infrastructure by ensuring that assets are effectively operated, maintained, and optimized.

Collaboration among asset owners, developers, and operators is crucial to ensuring that infrastructure is designed with long-term operational efficiency in mind. Developers must align with asset owners' objectives to ensure that designs and builds reflect the needs for sustainable, efficient asset management. Operators, on the other hand, must focus on maintaining the asset's performance and supporting its lifecycle management, utilizing the data generated during its operation to optimize efficiency.

Key Actions:

- **Strategic Stewardship**: Asset owners must adopt a strategic role, balancing operational needs with long-term sustainability.
- **Collaborative Partnerships**: Ensure seamless collaboration between asset owners, developers, and operators to meet both immediate and future needs of infrastructure projects.
- **Maximize Asset Utilization**: Ensure that infrastructure investments are continuously optimized for performance and cost-efficiency.

5.3 Government's Role: Incentivizing Cross-Sector Adoption

The government has a central role in embedding asset management practices across all sectors. This includes incentivizing the adoption of best practices, creating an environment that encourages innovation in financial models, and ensuring that both public and private sectors are aligned in their asset management strategies.

Financial innovations, such as monetizing infrastructure assets or forming PPPs, offer new revenue streams and ensure that infrastructure investments remain sustainable. The government

should not only set policies but also encourage these innovations through incentives and frameworks that support the long-term commercialization of public assets.

Key Actions:

- **Policy and Framework Support**: The government must integrate asset management principles into every stage of infrastructure development, from planning and procurement to operation.
- **Financial Innovation**: Create policies that support the monetization of infrastructure, including revenue-generating opportunities through asset commercialization and PPPs.
- **Incentivize Collaboration**: Foster cross-sector collaboration by encouraging private sector participation through policy incentives and outcomes-based contracts.

5.4 Building Workforce for Asset Management: Role of Educational and Training Institutions

Educational and training institutions play an essential role in preparing the next generation of asset management professionals. With the increasing complexity of infrastructure projects and the evolution of asset management practices, there is a growing need for specialized education and training programs. Universities and professional bodies must ensure that curricula align with global best practices in asset management, lifecycle thinking, and financial innovation.

As the Kingdom embraces new asset management models, these institutions must bridge the gap between traditional engineering education and the new skill sets required to manage modern, digitally enabled infrastructure. This includes offering certification programs in asset management, lifecycle planning, and financial modelling to ensure a skilled workforce is available to support the transformation of Saudi infrastructure.

Key Actions:

- **Develop Specialized Programs**: Universities should offer programs in asset management, financial modelling, and lifecycle planning to prepare professionals for the evolving industry.
- **Align with Industry Needs**: Partner with government and industry stakeholders to ensure educational content remains relevant and aligned with national goals.
- **Create Certification and Development Programs**: Offer continuous professional development and certification to equip professionals with the necessary skills for modern asset management.

Conclusion: A Unified Vision for the Future of Asset Management

Saudi Arabia's journey toward realizing Vision 2030 depends on its ability to embed asset management as a strategic function throughout every phase of infrastructure development. The Kingdom faces significant opportunities to enhance the value and performance of its infrastructure, but this can only be achieved through collaboration across stakeholders and the integration of digital technologies.

The government, private developers, asset owners, and educational institutions must each play their part in driving this transformation. By establishing clear policies, promoting cross-sector collaboration, investing in technology, and ensuring that the workforce is adequately trained, Saudi Arabia can develop a robust, data-driven asset management ecosystem that ensures the long-term success of its infrastructure projects.

This transformation requires a comprehensive approach that integrates asset management principles into capital planning, procurement, and operations. The government's role in incentivizing financial innovation, fostering collaboration across sectors, and supporting education and training will be critical to embedding asset management as a strategic priority across Saudi Arabia's infrastructure ecosystem.

The path forward requires a collective effort to embed asset management into capital planning and procurement, prioritize lifecycle thinking, and embrace the potential of digital tools. By taking these actions, Saudi Arabia can build a sustainable, efficient, and resilient infrastructure that supports the Kingdom's broader economic and societal goals. Ultimately, strategic asset management will play a key role in making Vision 2030 a reality, ensuring that infrastructure investments are optimized to deliver long-term value for the Kingdom's citizens and future generations.

About Galambos Consulting & Management Partners

Galambos Consulting Co., W.L.L. provides specialized asset management consulting and training services, catering to organizations that rely on assets to produce goods or deliver services. The firm works with both private and public infrastructure asset owners, engineers, architects, and asset management consulting firms, offering tailored solutions to optimize asset performance. Their clients benefit from expert guidance in scaling asset management capabilities, ensuring that long-term service levels and stakeholder expectations are met.

With decades of experience, Galambos Consulting excels in conducting asset management maturity assessments, evaluating organizations against global standards such as ISO 55001:2014, and providing insights into areas for improvement. The firm is skilled in developing Asset Management Systems (AMS), creating strategic Asset Management Plans (SAMPs), and implementing tactical Asset Management Plans (AMPs). They provide gap assessments, roadmaps, and comprehensive change management strategies to ensure the smooth integration of these systems within organizations.

The firm is also known for its asset investment planning services, which consider the entire lifecycle cost of asset ownership, from acquisition to decommissioning, and analyse operations and maintenance expenditures. Additionally, they provide in-depth risk evaluations to help organizations forecast total expenditure and mitigate asset-related risks.

Galambos Consulting serves a diverse range of industries, including aerospace, automotive, energy, facilities management, oil, gas, and telecommunications. They offer training programs tailored to the needs of organizations at any stage in their asset management journey, ensuring that the workforce is equipped with the skills to implement and sustain best practices.

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In particular, we have built a strong track record in infrastructure and asset management, helping organizations optimize their asset lifecycles and enhance operational efficiency. Through the integration of advanced digital tools such as IoT, AI, and BIM, we assist governments and enterprises in developing robust asset management systems, ensuring they can derive long-term value from their infrastructure investments. We provide tailored strategies that focus on improving governance, risk management, and regulatory frameworks, enabling clients to adopt innovative solutions that drive both economic growth and sustainability.

Management Partners brings extensive experience in the Middle East, including strategic initiatives aimed at transforming the region's infrastructure landscape. Our work in infrastructure focuses on advancing smart city initiatives, improving urban infrastructure, and fostering innovation through digital solutions. By leveraging in-depth market insights and practical policy recommendations, we support local governments in delivering cutting-edge infrastructure projects that align with national development goals.

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Endnotes

1. *Galambos Consulting Co. W.L.L*

2. *Ahmed Murtaza, A. Saher, M. Hamza Zafar et al. Results in Engineering 24 (2024) 102935 ; Fig. 2. Trend of enabling technologies in Predictive Maintenance (2015-2023).*

3. *Ahmed Murtaza, A. Saher, M. Hamza Zafar et al. Results in Engineering 24 (2024) 102935 ; Fig. 8. Industry 5.0 framework of Predictive Maintenance and Condition Monitoring.*

4. *The Institute of Asset Management 2024: An Anatomy of Asset Management*

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