Effective Infrastructure Asset Management

A holistic approach to transformation

Russell Pell, Radek Svoboda, Rick Eagar, Peter Ondko, Frank Kirschnick

Ensuring that physical assets are available to deliver required services in a cost-effective and timely fashion is a big issue for industry. Assets managed across the European Union are worth some €48 trillion, and investments of €1.9 trillion and maintenance expenses of €1.0 trillion are required annually to keep them going. Given these numbers, one might be forgiven for thinking that after decades of development and refinement, asset management prac-

It would be easy to assume that after decades of development and refinement, infrastructure asset management practices and approaches would now all be fairly straightforward and well-established.

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tices and approaches would now all be fairly straightforward and well-established. However, this is not the case at all. For example, in a recent benchmarking study we found that some of the world's leading infrastructure companies are still struggling to implement even basic predictive maintenance techniques effectively. Many are facing mushrooming costs to maintain and replace aging assets, whilst demands for reliability and capacity are constantly increasing. All this means that many infrastructure companies are starting to realize that they can no longer manage assets in the same way – a radically different approach is needed. In this article we explore the challenges being faced by infrastructure companies in transforming their asset management processes, and set out some best practices to help transform operations.

However, many companies are realizing that in the face of mushrooming asset replacement costs and increasing demands for reliability and capacity, a radically different approach is needed. In this article the authors explore the challenges being faced by infrastructure companies in transforming their asset management efforts and set out some best practices to successfully make the change.

The challenges facing infrastructure companies

The principles and methodologies for effective asset management are well established and enshrined in commonly accepted standards such as PAS55 and ISO 55000. However, not all industries have reached the same level of maturity in their approach to managing their assets. Whilst sectors such as aviation, chemicals, manufacturing and nuclear power are quite sophisticated in their asset management approaches and technologies, other infrastructure sectors such as rail, road, oil & gas and water are often less so.

There are some good reasons for this. Asset management is generally more difficult when assets are distributed over large distances with differing origins, ages and operating conditions. Also, many infrastructure systems are publicly owned and regulated, and historically have not been subject to the same commercial pressures for optimization as, say, a manufacturing plant.

In recent years there has been growing pressure on infrastructure organizations to significantly improve their asset management performance. This is due to a range of factors, such as the need for increasing capacity due to economic growth and urbanization, the need to replace high-cost, aging assets in developed economies, shrinking public sector budgets, and ever-higher demands from customers for infrastructure service quality and reliability. In addition, rapid technological innovation in areas such as big data analytics, robotics, automation and sensors, is opening up new possibilities that transform the way assets are managed.

However, today we see that many infrastructure organizations – even the best-performing ones – are struggling to achieve the scale of transformation needed to respond to these growing pressures.

Where infrastructure companies are struggling

We see a number of common problems that infrastructure companies experience, for example:

- Many companies do not yet have a fully-integrated approach to **demand forecasting, demand management and asset planning**. This makes it difficult to establish asset management strategies that will optimize across new asset builds and extensions, existing asset replacements or enhancements, and maintenance or rehabilitation regimes.

- Second, most companies have some type of **asset information system** for planning and work-order management, but often this is not yet integrated into a single architecture, and actual real-time condition data may not be included in the system. The resulting lack of accessible information at the right time, in the right place, is a major barrier to efficiency improvement.

- Third, although **whole-life costing** is usually in place (i.e. evaluating total costs over the lifetime of the asset), in practice it is often poorly applied because of grey areas around key assumptions and fragmented responsibilities internally. Connected with this is an approach to value management, which, whilst recognizing "value engineering" (i.e. optimizing designs on the basis of analysis of the value they provide), seldom leads to significant design changes with major cost or performance benefits due to a "stick with what we know" mentality.

- Fourth, implementation of optimization techniques such as **condition-based monitoring and predictive maintenance** often gets stuck at the pilot stage. This is because of the time and level of effort needed to analyze and interpret huge volumes of condition data, its uncertain economic benefits, and the complexity and cost of full rollout.

- Finally, many infrastructure companies have a strong focus on high operational reliability, which leads to a **risk-averse culture** with respect to new and emerging technologies. Many companies have few, if any, dedicated resources for **new technology development and introduction,** which means they tend to stick with what they know.

So what should infrastructure organizations do to overcome these problems?

Using a holistic approach to achieve transformation

Our recent asset management benchmarking study showed that the most common underlying weakness in companies was a failure to address asset management **in a sufficiently holistic way**. Companies were often working on the pieces of the puzzle, especially in terms of predictive maintenance technology trials, but had failed to put them together in a way that would achieve a real impact.

The companies that have been most successful in transformation are those that have taken a holistic approach that tackles these underlying weaknesses head on. This approach comprises five building blocks: Requirements, Systems, Principles, Methods, and Organization & Culture, as shown in Table 2.

1. Requirements: Integrated strategic asset management planning

The ability to form a consistent, properly evidenced, and integrated picture of likely demand on assets, especially in the medium to long term, is essential to enable optimized asset management plans to be developed. In many organizations this is difficult because of absent or separate "siloed" processes for short-term demand assessment, long-term demand forecasting, asset enhancement planning, and current asset degradation modelling and maintenance planning. Key steps to address this issue include:

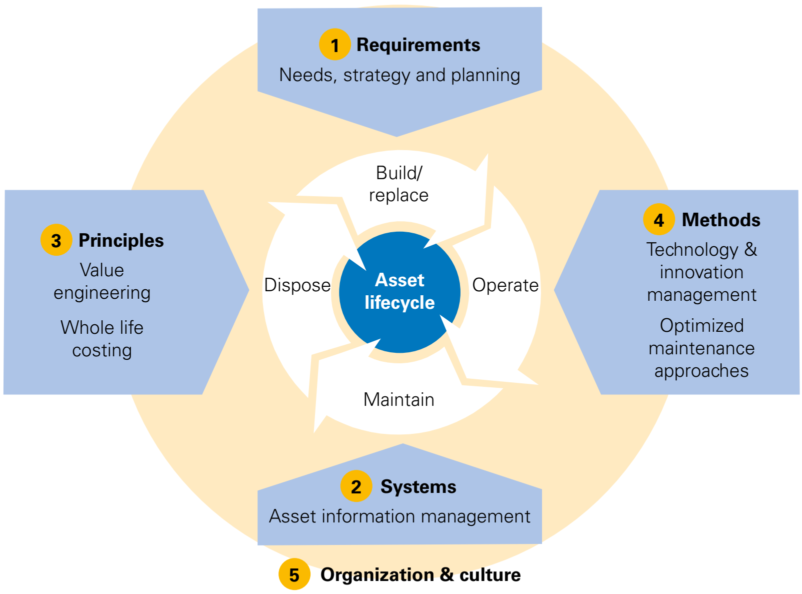

Table 2 **Holistic approach to asset management transformation**
Source: Arthur D. Little

- Setting up a **consolidated demand register** to capture the range of past, current and future needs on the assets, including, for example, customer needs, operational needs and strategic/ corporate needs.

- Re-engineering the **strategic asset planning process** to analyze consolidated demand needs as well as current asset conditions and degradation forecasts, and to develop integrated short- and long-term asset replacement and management strategies.

- Leveraging new **technologies and approaches** to improve demand intelligence, such as new big data analytical methods, new ways of monitoring, modelling, and predicting customer behaviors, and new trend intelligence and forecasting tools.

As one example of the value of demand management, the Fuel Efficient Traffic Signal Management program implemented throughout the State of California optimized traffic signal timing by enhancing data collection, system monitoring and automated control. This led to improvements in overall system utilization and a cost-benefit ratio of 1:17. This was achieved by reductions of 14 percent in delays, 8 percent in fuel consumption, 13 percent in stops, and 8 percent in travel time, all without requiring significant investment in existing infrastructure.

2. Systems: Adequate asset information management

Having accessible and suitably-interpreted asset information is a critical enabler for the entire asset management effort, in order to support the planning cycles appropriate to that asset type. To manage disruption, this could mean very short-term, or even real-time, data. Despite its importance, many companies do not recognize the strategic value of asset information. Information system issues are often complex and IT-based solutions may be costly, meaning that companies are reluctant to make the necessary investment. There is usually a wide variety of implementation paths available, but the most successful approaches tend to focus on three things:

- **Getting the fundamentals in place.** Making sure that the basic information for all key assets is actually available to support key asset management processes and performance analysis. Ideally there should be a commonly agreed suite of technical, operational and condition information, in a fit-for-purpose data structure to enable rapid development of builds to the information.

- **Leveraging the information.** Once key data is available and accessible in a coherent structure, it needs to be used to create efficiencies. This means new processes, maintenance strategies, ways of working, and competencies. Creation of reliable asset degradation models is one of the key means by which good-quality asset-level data on operational history and conditions can be used for maintenance optimization.

- **Information integration.** With key data available and supporting new ways of working, there is an opportunity to further integrate asset information. This usually involves finding ways to better integrate with enterprise solutions and other applications within a connected portfolio.

As with any information system, it is often valuable to **stagger the development**, so in effect the deployment of change is happening across different asset groups at different stages at the same time, and quick wins can be delivered through well-facilitated pilots. The focus should be on how new ways of working by engineers and technicians will deliver the benefits of improved asset information availability.

Advances in **digital technology and solution development methods** mean that the development of asset information management is no longer a binary choice between simple solutions based on limited technology investment, or highly complex approaches requiring substantial investment. In fact, we see companies adopting three levels of approach here:

- MVP (Minimum Viable Product) – low-tech options, with multiple manual workarounds
- Pragmatic approach – digital "fit-for-purpose" often incorporating agile development
- Enterprise-level solutions based on fully integrated systems requiring high levels of investment

Choosing the right approach can greatly reduce investment costs without compromising on functionality. With the increasing use of **agile development techniques**, organizations are now seeing that technology can be developed in certain areas within rapid timescales, not necessarily related to the long-term asset lifecycles which tend to characterize the traditional mindset of the asset manager.

3. Principles: Consistent whole-life costing and value management

The concept of optimizing whole-life costs (TOTEX) as opposed to managing CAPEX and OPEX separately has been around for many years. High initial acquisition costs may provide assets with higher reliability, better performance and lower maintenance costs, whilst low acquisition costs can generate higher OPEX costs in the future. Many companies still only pay lip-service to the concept and do not apply it effectively and consistently. Common reasons for this include, split budget responsibilities between OPEX and CAPEX; short-term financial constraints which favor CAPEX reduction over TOTEX; and different assumptions about asset lifetimes, cost allocations, depreciation curves, and the economic value of benefits across different parts of the company, which undermine the credibility of the approach. Often organizations struggle to effectively prioritize their asset-related budgets or portfolios, because of difficulties in comparing different projects in the portfolio on a common basis. This is sometimes due to attempting to apply highly detailed project parameters for comparison, when in reality a more holistic approach would better achieve what is needed. Key success factors for companies in applying an effective whole-life costing approach include:

- **Embedding a whole-life view into all aspects of the asset lifecycle:** Adoption of a genuine, shared, long-term view on asset lifetime cost and performance, supported by top management, is an essential starting point. The whole-life approach is applicable in all stages of the asset life cycle, including Design, Operate, Maintain and Dispose. It should be applied to suit the needs of the organization as a whole, which may be different to the needs of planning or managing a specific project.

- **Agreeing common definitions and assumptions:** Having clarity across different functions, departments, business units and regions around key definitions and assumptions is essential to underpin the credibility of the TOTEX approach. This can sometimes be quite difficult, given the varying lifetimes of different asset classes, cost allocation complexities, and the challenge of monetizing certain performance benefits.

Value management is also a key part of the picture in terms of optimization and achieving cost efficiencies. Like whole-life costing, value engineering has been around for many years but is still poorly implemented by many companies. Typical problems include risk aversion when considering alternative design technologies, lack of in-house capabilities to assess options and impact, and reliance on design contractors to conduct "value engineering" studies too late in the cycle, when the basic design concept has already been frozen. Key success factors for effective value management include:

- **A focus on innovation and "optioneering":** avoid the automatic assumption of like-for-like asset replacement, and change the policy of using only well-established technologies or designs. Manage risks rather than avoid them. This is especially important for assets with long lifecycles, when many new options may be available, and crucially, knowledge of prior design assumptions may have been lost in the course of time.

- **Multi-disciplinary, function-based thinking:** Good-value management starts by considering what the function (or set of functions) is that the asset needs to deliver. Asset owners and managers should work with multi-disciplinary teams including project managers, operators, designers, estimators, contractors and commercial staff, based on a structured process. Too often, operators or asset owners rely on their contractors, instead of taking the lead to ensure that they are getting exactly what they need in a cost-effective way.

- **Timing:** Strategic value-based thinking for assets should start very early on, certainly around the time concept design starts. Having a layered approach, whereby high-level direction can be set early, and then focusing on specific aspects or areas in more detail later on, can help to ensure that the complexities of specific projects are considered appropriately.

These principles deliver major benefits. For example, in Germany, transmission grid operators have started to prioritize more systematically their capital investments for grid/sub-station operations and onshore/offshore grid connection projects using effective whole-life approaches. In Denmark, analysis of policy options has reduced the costs of road maintenance by 10 to 20 percent, whilst reducing the maintenance backlog by 70 percent.

4. Methods: Predictive maintenance and technology & innovation management

Whilst of course, there are many methods and approaches that need to be applied for effective asset management, there are two methods which have a big potential impact by addressing the typical weaknesses mentioned above as part of a holistic approach: predictive maintenance (PdM) and technology & innovation management (TIM).

PdM is a powerful tool for optimization because it enables:

- Reduced maintenance costs by optimizing maintenance schedules, based on the prognosis of future asset conditions.
- Improved system reliability and minimized disruptions through better failure modeling and prediction.
- Reduced downtime through better maintenance planning and execution, based on foresight rather than history.
- Extended asset life through better intelligence on asset conditions and management of asset degradation.

As mentioned above, there has been tremendous innovation in technologies relevant for PdM in recent years (see Box 1), with the potential for game-changing impact.

Box 1: Technological innovation in maintenance: From predictive to "prognostic"

Technological innovation in maintenance covers many fields, including condition-monitoring technologies, remote control and automatic tools, workforce management, and analytics and big data solutions.

New condition-monitoring technologies enable precise targeting of maintenance and repair activities to assets with signs of deterioration, for example:

- Surveying cars equipped with high-resolution cameras, laser systems and other sensors are increasingly used to monitor remote asset condition and quality. Techniques using drones and robots have huge potential.
- New types of condition data have been discovered. In the case of rotating equipment, examples includes stress waves, filter debris, and stator vane acoustics (indicating blade cracks) for gas combustion turbines.
- New types of sensors have been developed for new and established data types, such as wireless, self-energized vibration sensors for upstream oil & gas applications, online/inline oil particle counters for wind turbines, and wayside laser sensors for railway applications.

Condition monitoring **combined with predictive analytics and big data** has given rise to **"prognostic" maintenance,** (i.e. building a comprehensive prognosis of future asset condition, as opposed to simply comparing the current condition with a predicted reference state). This is now possible on a much larger scale, as highly affordable ways of transferring, archiving and processing data in large volumes have emerged, with cloud computing and storage now finding their way into industrial asset management. Predictive and prognostic maintenance is increasingly being adopted in more dispersed asset bases, such as transmission networks and high-speed railways. Adding high-quality, yet low-cost, mobile communication devices such as smartphones or tablets enables almost complete digitalization of workforce management, leading to substantial reductions in scheduling efforts and improved utilization of field workers in operation and maintenance.

With "Industry 4.0", the "Industrial Internet" and the "Internet of Things" (IoT), new analytical solutions – including prognostic solutions – from other industries such as finance, consumer goods and healthcare are now entering the realm of industrial asset management. Grounded in big data and decades of analytical refinement in highly competitive markets, best-practice solutions from these sectors may prove inherently more powerful than the old-fashioned analytical approaches used for PdM. Robust stochastic process models, in particular, integrate and utilize the available condition data volumes without requiring asset-failure rates or lifecycle statistics, formerly mandated by legacy techniques such as Weibull fitting and Cox regression.

Organizations need to ensure that asset failure/degradation models are developed and validated, possibly in consortiums or joint ventures with industry research institutes. This will allow them to gauge where best to apply PdM as part of a balanced maintenance approach that includes preventive and reactive methods. Once suitable asset information systems are in place (see 2 above), it is possible to "mainstream" PdM methods into maintenance processes. In combination with innovative mobile workforce solutions, remote-monitoring techniques and automatic/robotic inspection and repair technologies, significant benefits can be achieved. For example, Xcel Energy, a major US electricity and natural gas company, implemented a digitalized, integrated solution for workforce planning and asset management, which included mobile functionality. The solution provided a clear, accurate, and timely data matrix that allowed overall optimization of major business processes, yielding an 87 percent reduction in scheduling effort, 17 percent reduction in maintenance and inspection effort, and 47 percent improvement in construction crew productivity.

In order to be able to successfully apply the new technologies that are being developed around asset management, **robust technology and innovation management approaches** are needed, combined with suitable resourcing. However, many companies do not yet have these approaches in place in the arena of asset management. Key elements include:

- **Systematic monitoring and evaluation** of emerging technologies, always considering their compatibility with existing assets.

- Adopting **partnering approaches** with developers, large suppliers and other innovation players to influence the course of technological innovation, co-develop solutions to meet internal needs, and build new internal capabilities and competences.

- Proper **piloting of field technologies** with practical lessons embedded during full roll-out.

Without these approaches, asset managers remain in reactive mode with regard to new technologies, and true integration into new and existing assets is difficult.

5. Organization and culture: Dealing with the root causes

The root causes of failure to achieve expected benefits from new asset management technologies, processes and approaches can often be traced back to fundamental issues around "people" and how the organization behaves. This relates especially to how responsibilities for different aspects of asset performance are defined, and where costs and benefits are allocated. Getting this right is perhaps the most essential part of any holistic approach:

- **Organizing around asset management:** Having the right organization structure and governance to enable teams and individuals to deliver world-class asset management is key. Asset management cuts across traditional company functions such as Engineering, Projects, Operations, Maintenance, Safety and even Customer Service. Accountability for asset performance is often split between these functions. Allocating clear accountability for asset lifetime performance within the existing structure is one way forward. A multi-functional governance approach, such as a cross-functional steering group or committee, can help to make balanced asset management decisions. In some situations, placing asset management in a more central position within the organization is the optimal answer.

- **Philosophy and culture:** Whole-life and whole-system thinking is often difficult to promulgate in the face of short-term corporate priorities, and pressures on departments, units and individuals to deliver against specific targets. Companies need to actively promote the right values and behaviors to support a holistic approach to asset management. This means leading by example, and reinforcing this with carefully selected incentives and key performance indicators that promote long-term goals and whole-system benefits. Early delivery of beneficial change is one important aspect. The use of rapid action teams, delivering substantive change in a specific area or asset class, is one proven technique for the advancements of new process management.

Insights for the executive

Infrastructure asset management companies need to do things differently to respond to the demands of today and tomorrow. The key to successfully making the change is to take a holistic approach that tackles fundamental barriers around Requirements, Systems, Principles, Methods, and Organization & Culture.

With these building blocks all in place, infrastructure organizations should be able to achieve the transformation they need in a sustainable way. Those that continue to approach asset management in a "siloed" manner, expecting new technologies alone to make the difference, are unlikely to succeed.

Russell Pell
is a Partner in the London office of Arthur D. Little and a member of the Operations Management Practice.

Radek Svoboda
is a Manager in the Prague office of Arthur D. Little and a member of the Energy & Utilities Practice.

Rick Eagar
is a Partner in the London office of Arthur D. Little and global head of the Technology & Innovation Management Practice.

Peter Ondko
is a Manager in the Prague office of Arthur D. Little and a member of the Operations Management Practice.

Frank Kirschnick
is Chief Technology Officer of Cassantec, a provider of prognostic solutions for industrial asset management.