White Paper

Asset Monitoring, Management and Optimization

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1 Introduction

Critical assets sit at the heart of industry. They are integral to the safe and profitable delivery of the services that businesses depend upon. Their scale, which depends intrinsically upon the business domain and nature of the service, can range from power line grids and underground pipelines down to a single tiny battery. The common factor is the importance of their particular link in a complex service delivery chain. The business challenge is to keep these key assets operational for as long as possible without sacrificing reliability or safety, at an acceptable cost. For each scenario the right balance has to be found between the likelihood of failure, and the associated impact.

A carefully planned and implemented maintenance regime, appropriate to each asset, is used to mitigate the risk of failure. If this maintenance regime is insufficient or neglected, deterioration in asset condition will increase the risk of triggering an escalating sequence of damaging consequences. With luck, the damage will be limited to unscheduled downtime and lost production. More catastrophic failures, can impact health, the environment and personal safety. Asset failures don't have to be on the scale of the Deepwater Horizon explosion or the Potter's Bar points failure to have significant business and personal repercussions. The tight schedules to which our modern 'just in time' world are run, causes the effects of asset failure to cascade rapidly far beyond their origin. An overly rigorous maintenance plan, however, will cause problems at the other extreme. The loss of profit resulting from high operating costs and high levels of planned maintenance downtime can undermine an otherwise sound business plan.

A systematic and responsive approach to asset management is the key to mitigating successfully this competing set of risks. The first requirement is accurate, up to date information about the provenance and current state of the assets. From this sound base, predictions can be made and acted on, with a potential to deploy systems to track changes in asset condition. With sufficient knowledge, collected at the right time, maintenance schedules can be updated dynamically to react to the latest trends. Real-time condition monitoring systems can deliver drastically reduced lifecycle costs, while still ensuring that service delivery remains reliable and efficient. The dominant factor is often the organizational challenge of responding effectively to a changing situation, rather than the technical ability to detect it in the first place. Early warning of potential failure, via sensitive recognition of pre-cursor behaviour, is the principal aim. Available manpower can then be directed where most needed, armed with details of the current problem and the context of previous failures.

This supplement explores how automated asset monitoring leads to better asset management, allowing organizations to optimize both operational and residual asset value.

1.1 Asset monitoring – the essentials

The premise behind all asset monitoring solutions is essentially the same, whether simple local instrumentation or highly integrated systems with distributed reporting and response scheduling. Asset condition and output is tracked for signs of failure or degradation, with timely reporting to allow either a maintenance intervention or a controlled shutdown before a critical, 'in-service' failure. The information collected is used to maintain an up-to-date asset register, a central source of truth regarding the nature, location, condition and performance of the assets across the business. Asset monitoring systems allow maintenance plans to be optimized, increasing asset availability and enabling any unavoidable downtime to be predictable and used most productively.

Digging behind the industry buzzwords of 'reliability centered' and 'condition based' maintenance we find the concrete and measurable benefits of the **RAMS** approach:

- **Reliability:** Unforeseen disruptions to operations can be minimized, increasing confidence in the overall system with more ambitious planning
- **Availability:** The overall uptime of individual assets is maximized, serious problems (which require time-intensive repair) are reduced and asset output is high
- **Maintainability:** Better, more timely, information on the condition of assets, and their degradation characteristics , streamline maintenance regimes and make optimum use of time and resources, keeping assets in better shape and reducing unforeseen problems
- **Safety:** Accurate and comprehensive data means that early warning can be given of possible safety-critical problems, and thus accidents can be prevented

Additional business benefits flow from these ‘behind the scenes’ changes. Throughput achieved per employee increases as greater workloads can be taken on. Reductions in production delays mean that customers can rely on orders being fulfilled on time. At the same time operational costs are minimized as equipment lasts longer, unnecessary replacements eliminated and spares obtained on a ‘just in time’ basis. It quickly becomes apparent that asset monitoring has the potential to deliver significant benefits across many facets of business reliant upon critical infrastructure. Such systems have been deployed successfully in industries as diverse as rail, power generation, manufacturing and petrochemical refinement and distribution. Deployment has covered both underlying infrastructure, such as the fixed rail network, and the specific points of delivery that utilize the infrastructure, such as individual train fleets.

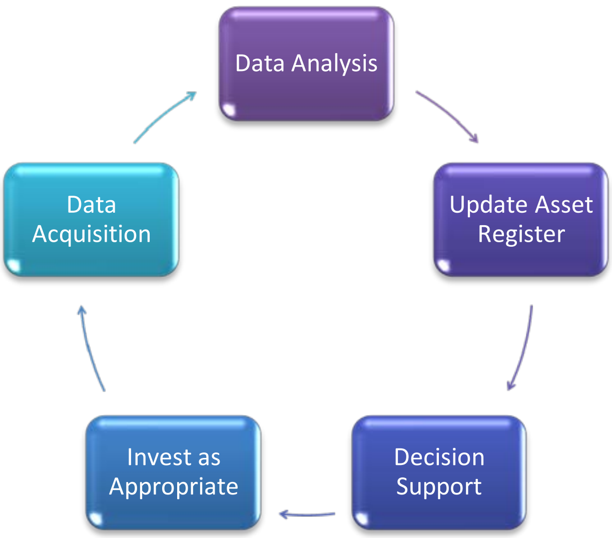
The greatest benefits are often found in industries where the accessibility of the infrastructure is limited, through wide geographical dispersion or when individual units are, for example, buried or in a contaminated environment. Situations where manual monitoring is either physically impossible, or not economically viable, see automated remote data collection and analysis making a real difference. Not only large-scale industries stand to benefit. With the appropriate modular design and simple core technologies, asset monitoring systems can be scaled to almost any environment.

Assets do not operate in isolation. Their condition and performance depend also upon their physical environment and the actions of the people or systems that operate them. Monitoring systems that also collect and analyze information on these additional areas take asset management and optimization to another level. The operational information can be used to drive staff training programmes that promote more efficient use of the assets. This further reduces component wear and tear and energy consumption, increases asset life and lowers running costs.

Asset Monitoring Technologies

Asset monitoring system designs vary as much as the industries that use them. At the core of each design, however, will be found some common principles:

1. **Data acquisition** – capturing information about the status of the asset being monitored
2. **Data analysis** – inferring the current state of the asset, or its environment, from the acquired data, predicting future asset state and flagging early warnings of problems
3. **Update the Asset Register** – capturing the results of monitoring into a central ‘source of truth’ for the organization’s asset base
4. **Decision support** – help to allow the best course of action to be identified, based upon the results of the latest data analysis and previously collected ‘historical’ data
5. **Investment** – developing and implementing an appropriate strategy for inspection, maintenance and renewal



Each of these principles in isolation is mature and well understood – asset monitoring simply combines these approaches in an intelligent and integrated way. There will always be some monitoring that can be best achieved manually. This can be evaluated in combination with more automated monitoring to provide a comprehensive picture of all related assets and consequences across the entire business. Many industries face the challenge of having to run complex assets for many years after the original system architects and developers have retired. Faced with the prospect of running without this expertise on the ground to diagnose and trouble shoot problems, asset management systems with built in intelligence are increasingly being turned to. These have the combined experience of previous generations built into the data analysis and decision support components.

In addition to these core features, a more sophisticated asset monitoring system could be expanded to include:

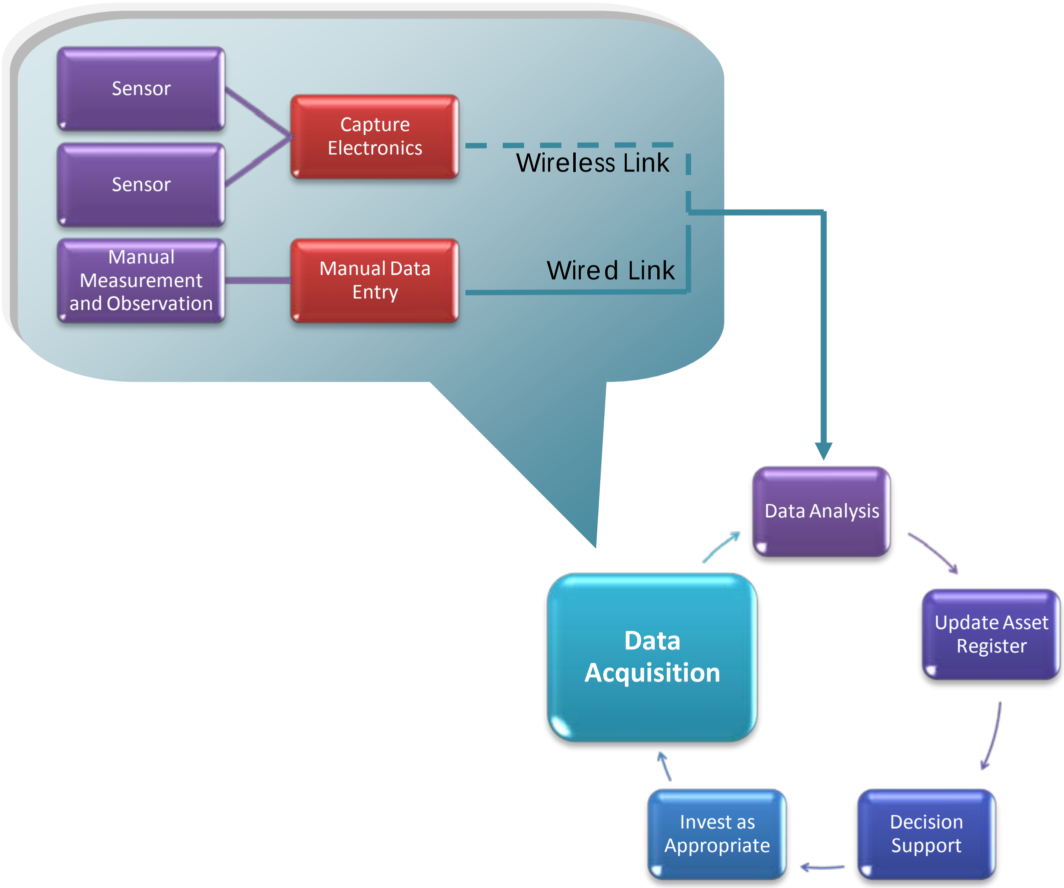
- Alerting systems, to inform staff when components fail and need replacing
- Persistent storage, to allow decision-making systems to review past behaviours as well as the current asset state, allowing trends can be identified and predictions made
- Automated, reactive scheduling systems, to create maintenance plans in real-time
- Fault modelling systems, e.g. decision trees to determine how and why assets fail
- Asset management and procurement systems, to order spare parts as they are needed ('just in time')

Each of these principles is explored in more detail below. As can be seen, asset monitoring systems can be tailored for a range of environments, from simple sensor monitoring to complex supply management solutions.

2 Data Acquisition

Observing the condition and performance of the asset itself through data acquisition is the first stage of asset monitoring. The design of the data acquisition stage is critical, as any conclusions drawn by the monitoring system, and all subsequent decisions made, will be based upon analysis of this data. Not only must the data acquired be accurate, the correct properties must also have been measured from the outset. Systems that also collect and analyze data describing the asset's environment, and the manner of its operation, will have a much wider context within which to judge current and future condition. An asset monitoring system's recommendations are only as strong as the data it receives.

Speed of data collection and transfer for analysis is also critical. If the measurements indicate that the asset has already failed, or will fail very shortly, then any delay is a failure of the monitoring systems and will have major cost or safety implications.



Data can be acquired from many sources. In order of increasing sophistication, an operator recording their 'impressions' of the equipment or other general observations, a technician recording accurate manual measurements, instrumentation making regular automated measurements. Train drivers frequently log ad hoc reports at the end of a journey, highlighting problems encountered or areas of concern. For assets such as computer servers, hardware monitoring software keeps an electronic eye on the asset. Downstream analysis of the data must always take account of the varied provenance of the incoming information if it is to interpret situations accurately.

Once asset property measurements have been taken, they need to be passed up to the monitoring and reporting system. Traditional wired connections, an increasing range of wireless network options, including wireless sensor modules, or operators doing manual (error prone!) data entry are all options of varying quality. Different methods of capture and transfer can be combined to optimize acquisition networks for the asset in question. As an example, assets in the transport industry are increasingly being fitted with a range of wireless communications options. If small data volumes are needed for real-time analysis and reporting, such as fault codes generated by on-vehicle intelligent systems, data streams over mobile networks are used. If however larger data volumes are needed for detailed off-vehicle analysis, the acquired data is often cached on the vehicle and then off-loaded in batches via WiFi at designated access points such as stations or depots.

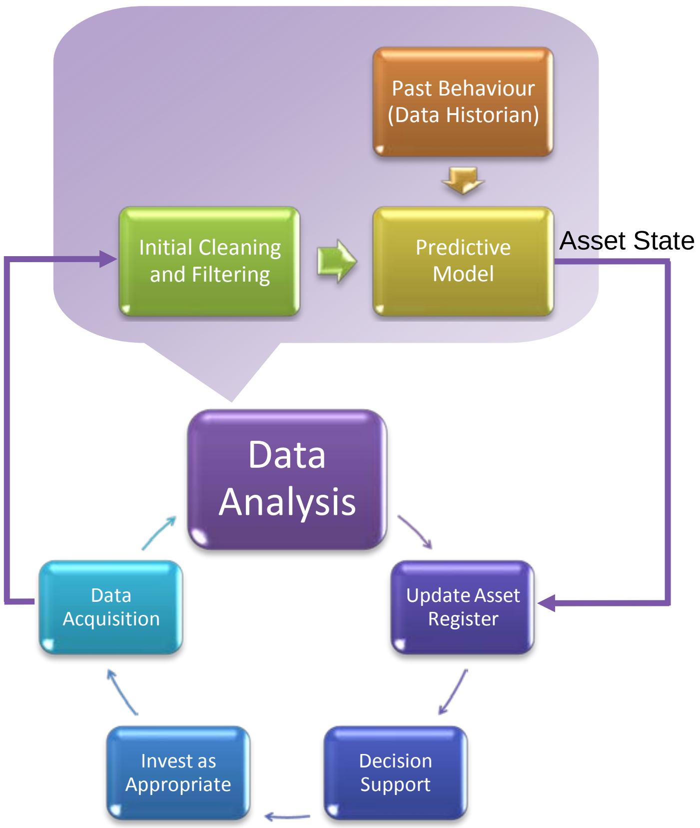
Automated data acquisition has countless advantages over traditional manual measurements:

- It is less labour intensive. Advanced sensor packages can calibrate themselves periodically and diagnose faults, reducing the sensor-servicing overhead further
- Measurements are often made to greater precision, the frequency of these measurements can be adjusted quickly and easily, and they are not prone to transcription errors
- Sensors can be placed in environments hazardous to human operators, or in remote or inaccessible locations
- Data from automated sensors can be returned instantly to a single location for analysis automatically

For example, a rail network may have strain and displacement sensors mounted at strategic locations on a stretch of track, reporting data to a central control room. Such a system allows a diverse range of measurements to be taken in real time, without the time-consuming and potentially hazardous requirement of engineers manually observing live tracks. Instead, an engineer in the control room can monitor the entire network and respond to problems as they occur.

3 Data Analysis

Data collection is not an end in itself and delivers no end value unless additional processing is used to turn it into information about the current or future state of this asset.



This task can overlap or even be absorbed into both the acquisition stage and the decision making stage – some sensor packages will automatically resolve changes in the electronic properties of sensors into more useful measures such as strain or temperature, and decision systems can be built around changes in these direct measurements. Typically though, an intermediate analysis stage would be included to infer the real changes to an asset's status from raw measurements.

Analysis will typically apply the measurements from the real system into asset degradation modelling or condition/life-cycle forecasting. This model can be static, or dynamically refined – see section 6.1 on fault modelling.

In the rail network example, suppose that the acquisition system measures a sudden shift in the loading of a section of track. The data analysis system combines this data with information about the track's material properties and behavioural history. It discards expected shifts in loading due to trains, and determines that this section of track has been structurally weakened.

If the detailed behaviour of the asset, and its expected signatures under the full range of operating conditions, are well known and predictable then incorporating an accurate model of the asset into the analysis will strengthen diagnosis and assist in future decision making. A good example is of modern aeroplane engines, which have a high degree of telemetry and which are all set up to within very small tolerances. Normal behaviour for one instance of this asset type will be very similar to that of any other, and an absolute behavioural model appropriate.

Often, things are not so clear cut and the absolute behaviour of an asset may not be so well defined or need to be so restricted. It might be perfectly acceptable for different instances of the same asset type to perform within a wider allowable range provided it does so consistently. In these cases absolute models are usually too restrictive to add value. Assuming the asset has been set up correctly at the outset, the key aim of the asset monitoring solution is to detect, categorize and report changes in behaviour. This 'relative' behaviour approach is more flexible and easily applied to different asset types than an 'absolute' behaviour model. It has been used to great effect on a condition monitoring solution for an aging train fleet, with low levels of on-board technology that require a lot of manual setting up. No two trains in the fleet are set up alike, and the same can be said for any two doors on the same train. The asset monitoring system ensures that the key train components have been set up within allowable tolerances and that they remain stable. This has been the critical step forward that has allowed the train fleet to run more reliably.

3.1 The Data Historian

Although asset monitoring is driven by regular receipt of new measurement data, almost all asset monitoring systems will be backed up by some form of data historian. This could be using a traditional file structure, a custom database, a proprietary data warehouse, or a combination of methods.

Persistent storage allows a monitoring system to refer to an asset's past behaviour, when interpreting the latest measurements. This information can be used during the data analysis and decision making phases to improve predictions. Additionally, systems can be designed parametrically to allow their design to be refined over time – for example, a data analysis model can be updated based on past and current behaviour to better reflect the real-world (see section 6.1 on fault modelling).

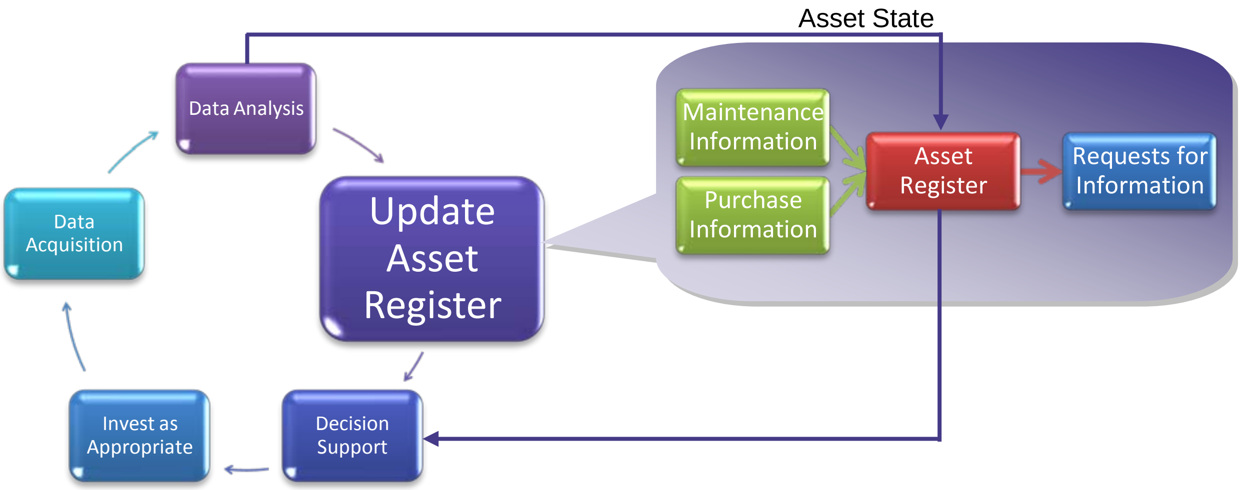
This delivers a big advantage of a system that can respond more accurately to asset changes and update itself over time to continuously improve performance.

4 The Asset Register

The Asset Register provides a centralized and coherent source of information on the full asset suite within the business, capturing the results of the previous acquisition and analysis phases. It acts as the single 'source of truth' with regard to the asset base. The scale and complexity of the register will depend not only on the size of the business but also on the volume of updates being received, and the frequency at which new assets are added or older assets decommissioned.

Key features of a successful asset register typically include:

- A unique identification for every asset
- Full details of the asset's origins – supplier, purchase and installation dates etc
- Comprehensive data on the asset's current status
- Information on who has responsibility for the asset and who owns it
- Appropriate links to financial and budgetary systems
- Details of historic and planned maintenance, including sources of funding where appropriate
- Ready availability of information to asset managers



In the rail network example, if a section of track fails, the Asset Register would be a major source of information in investigating the causes of the failure. It would contain the maintenance history, including when the section of track was last maintained, and by whom; it would contain the details of any parts used and how they were sourced. The Asset Register would also contain valuable information about the monitoring history, which could be examined for any signs of impending failure that were missed. If appropriate, this might then lead to changes in the predictive models used at the data analysis stage.

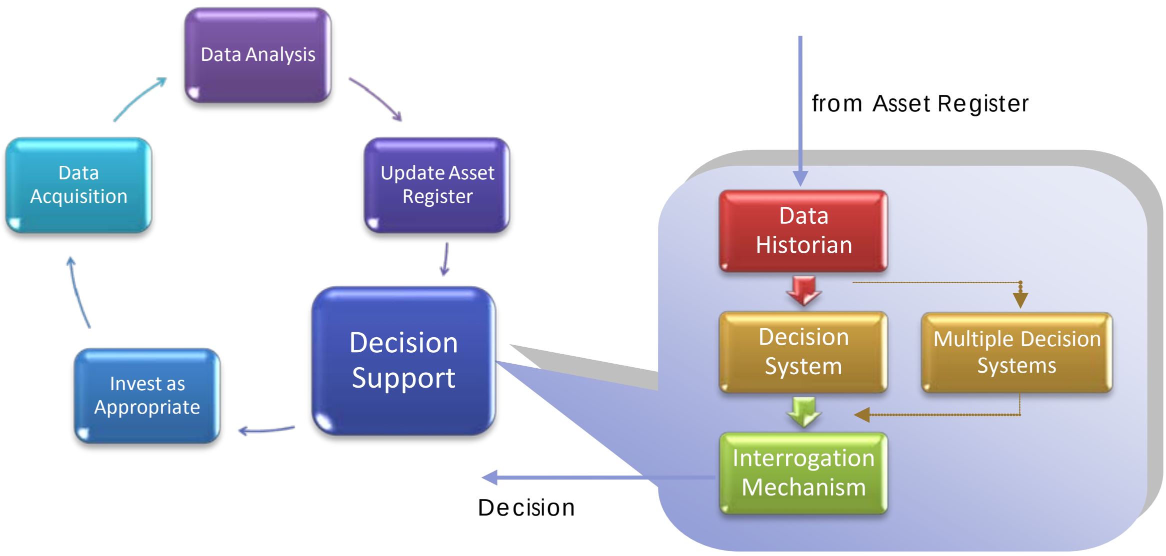
5 Decision Support

A decision support system (DSS) sits at the heart of every truly effective asset monitoring solution. The current state of the asset may be known, and a concerning rate of change in a property reported; but what should be the proper response? Which assets should receive priority maintenance next? Should they be repaired or replaced? Should there be a temporary shutdown, or isolation of specific assets? The DSS exists to help answer these questions. If it does not itself take decisions, it extracts and presents the information a manager needs to be empowered to take those decisions.

A complete description of decision support systems is beyond the scope of this supplement (see the Tessella 'Decision Support Systems' technical supplement), but an introduction is worthwhile.

Decision support systems are composed of two primary components:

1. A data store representing knowledge about a system
2. A method of systematically interrogating this knowledge



In the context of asset monitoring, the DSS takes information about the status of an asset and queries the data store as to how to best respond to the situation. The data store holds knowledge of the conditions that lead to an asset failure, how these conditions evolve and interact, and how best to resolve problems.

Having an effective decision support system is critical for the success of the whole asset monitoring system and developing one can involve gathering data from a variety of sources, mining and analyzing this data, and deciding upon the best way to implement the data store. This is a complex task, but the importance of a well-implemented DSS to a robust, efficient asset management system cannot be overstated. Many projects in this area fail because of an inability to use the generated information in a timely and effective manner, often because the general business processes either have not adapted to the existence of the monitoring system. The discipline of building a functioning DSS with clearly actionable responses helps integrate the technological solution into the functioning business.

A DSS can be implemented in numerous ways, but four of the most common implementations are:

1. **Expert systems:** Otherwise known as rule or knowledge systems, expert systems were devised in the 1970s and were initially used in the artificial intelligence and computer vision fields. More recently, expert systems are used as a method of encapsulating the knowledge of a human expert in a particular field, for example diagnosing skin problems. Expert system designers attempt to quantify the intuitive knowledge and 'rules of thumb' that experts use, and encapsulate them into logical expressions. These expressions can then be used to make decisions based on new data.

   Expert systems have a narrow field of expertise, and so are only useful when the problems they are designed to resolve fall into this field. Their strength is that they do not require an analytical model of how the studied system works, and so are useful when such a model is unavailable or inappropriate.

2. **Model based systems:** These work in a similar way to the data analysis systems described earlier. A mathematical model of how a system behaves is developed, and this model is used to predict the future behaviour of the system, based on inference from current measurements. As described above, by no means is it always possible to develop a representative and useful model of the system in question.

3. **Artificial neural networks (ANNs):** These use a linked network of nodes to make statistical decisions based upon given inputs. Traditional networks require a training period, during which the weighting of the links between nodes is modified using a known set of inputs and outputs. More recent designs, such as self-organizing maps, can avoid this training period to some extent. Certain networks can even incorporate notions of information cost, and request further input data when this may help the decision process.

   ANNs can be much more flexible than expert systems or models, particularly when dealing with uncertain or incomplete information. Decisions are not returned as simple yes/no answers, but rather as probabilities – the network can say how certain it is of an answer. Another strength of ANNs is that they can be developed without a physical model of an asset.

4. **Bayesian networks** are a middle ground between artificial neural networks and model based approaches. A statistical model of the asset's internal properties and their interaction is developed, and the most likely future behaviour can be predicted by feeding current and past behaviour into this model.

   Bayesian networks combine the flexibility and uncertainty tolerance of ANNs with the physical understanding that can come from modelling, but trade this for a longer development phase that requires both modelling and training periods.

There is an additional twist in DSS design in that a system may be a hybrid of more than one approach – for example, several heterogeneous systems could be arranged in a committee, so each system voted on the final decision based upon the asset's status.

Rather than simply offering the 'best' decision as the one to be taken, a DSS can offer a range of options together with estimates of their costs, risks and benefits.

In our rail network example, the DSS would receive information that a section of track had been structurally weakened, and adjust its failure time predictions for this section accordingly. Train timetables and the maintenance requirements of the rest of the network are consulted, and an optimal maintenance recommendation is formed. In the meantime, an appropriate speed restriction would be suggested to preserve safety until the situation is resolved.

A well-designed DSS alone is a beneficial system, and can assist with decision-making at a number of levels. When combined with automated data acquisition and analysis systems it becomes a powerful tool for protecting assets and optimizing their performance.

5.1 Fault modelling

By introducing fault modelling, an asset monitoring system can address a tangential problem to that of maintenance – *how* and *why* do assets fail?

Asset monitoring systems can process large volumes of information, and this can be used to propose, test and refine models of the physical system in question. These models provide a greater understanding of the asset's behaviour in real-world conditions, which can be used to identify assets that are over (or under) loaded and require more (or less) frequent maintenance. This information can even be fed back into the asset design process to improve future assets.

There is a second, more pragmatic use for fault models: evaluating the reliability of individual components within a system. When spares are used during maintenance, the performance of these spares can be inferred through deviations from existing fault models, and substandard parts can be replaced with superior ones. Likewise, when an asset of a new type fails, this information can be used to schedule inspections of other assets of the same type.

5.2 Alerts

When the monitoring system detects a change in the state of an asset that needs immediate or planned intervention, it is essential that this information is communicated in the form of a system alert as soon as possible, to the right recipient and using the right medium. To ensure timeliness of response, and to minimize the chances of any adverse effects, the system should detect and report the change as close to the occurrence as possible. There are many routes by which the alert can be communicated, with the optimal method being very system dependent. What is common, however, is the content that a helpful alert message should contain. These include:

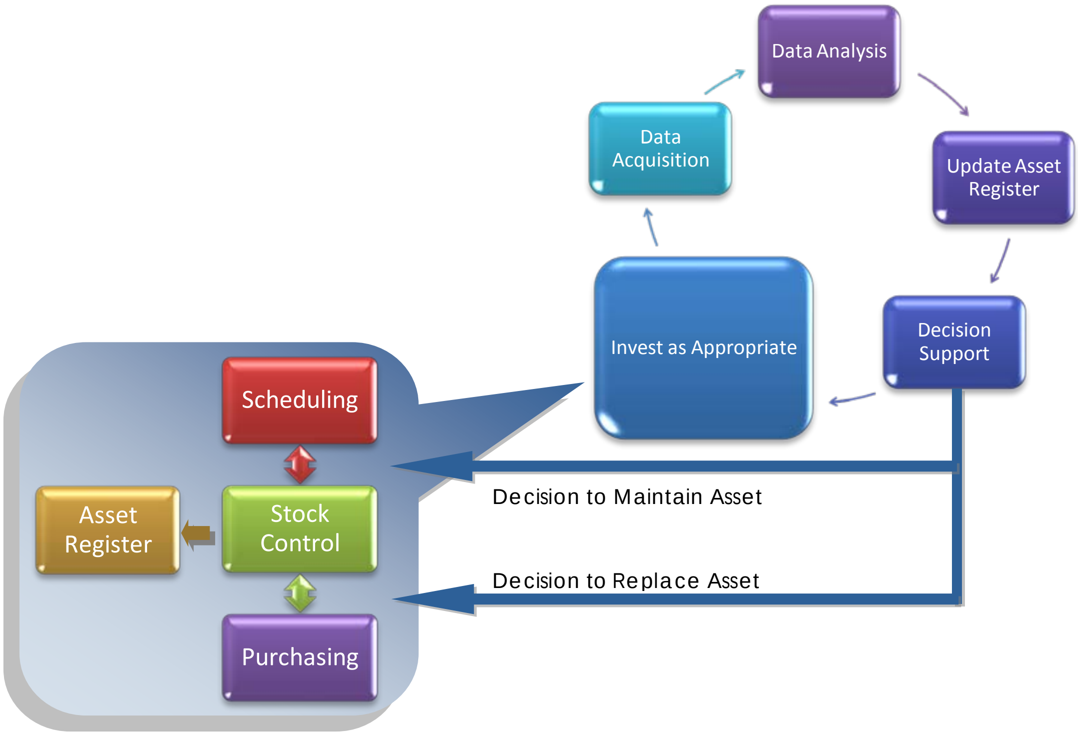
- identity of the asset involved
- date and time that the change occurred
- clear description of the change or event that has occurred
- the seriousness of the situation and a % confidence in the diagnosis
- if possible, a recommended course of action or person to contact
- more information about the asset (location, age, etc)
- history of this alarm (has it been acknowledged yet, by whom etc)

Whilst mature asset monitoring can greatly reduce incidents of catastrophic failure, occasionally they may still occur. By including features such as emailing or SMS messaging into the monitoring systems, key staff can be alerted to these failures immediately (even when away from monitoring screens), minimizing further damage to the asset. Integration with established technologies such as SMS messaging and email can be achieved simply and for a relatively low cost.

Historically, there are many high profile examples of where asset monitoring systems have been guilty of producing too many alarms, creating a 'Christmas tree' effect within control centres. The inevitable result is overload, no alarms are responded to and the system quickly falls into disrepute. It is essential that monitoring systems do not fire alerts at the drop of a hat. Instead, parameterized trigger mechanisms should be used, allowing rules covering how persistent the exception needs to be for each alert priority, before that warning is raised. This damping mechanism stops minor and isolated exceptions triggering alerts too early.

6 Investment and Asset Management

Any recommendation made by the DSS to maintain or to replace an asset is only useful if the work is actually carried out. Thus, decision support feeds directly into investment helping to provide an appropriate strategy for maintenance and renewal. This could be done manually, but in a highly integrated system the output from the DSS could feed straight into a scheduling system (which helps to plan the activities of the maintenance staff) and stock control and purchasing systems (to ensure that all the necessary parts are available). A system that covers all these areas is often referred to as an asset management system.



In a traditional modular business, asset management requires coordination between several departments, and the failure of any one department will render other departments' efforts useless. Asset management systems combine several of the technologies discussed previously in this supplement – monitoring, storage and communication systems – with additional systems such as inventory management and automated scheduling, to manage the entire chain of processes responsible for the day-to-day protection of critical assets. By integrating procurement, monitoring and maintenance, coordinating these systems is simplified and streamlined.

Asset management systems are modular, built around six key areas, each of which would be customized to individual business needs:

1. **Asset register** – the database used and updated by all other parts of the system
2. **Asset monitoring** – observing assets and proactively predicting maintenance needs
3. **Stock control** – making sure that spares are available in the right place at the right time
4. **Purchasing** – ensuring that spare parts are ordered as required
5. **Automated scheduling** – Coordinating maintenance plans to make the best use of service engineers
6. **Worksheet generation** – Providing service engineers with detailed instructions on what to needs to be done, what specialist tools will be required, etc

In the rail network example, the DSS would inform the scheduling system that some urgent track replacement is required on a given section of track. This would then check for availability of the necessary parts – flagging up any shortages to the appropriate purchasing system. Once part availability has been established, the next step would be to assign the work to a maintenance team and to schedule it in their calendars.

A well-designed asset management system puts asset protection and optimization at the centre of a business. Previously disparate systems work together systematically to ensure that assets can operate at peak performance, backed by the entire supply and servicing chain.

6.1 Stock Control

Stock control systems monitor and control the movements of components once they are acquired by a business, and ensure that they are available wherever and whenever they are needed. Stock control systems can be built upon similar technologies to decision support systems, and require the same careful design. They are often closely linked to purchasing systems, as both are responsible for asset supply maintenance.

The movement and location of parts can be tracked by several methods. One recent method is through the use of RFID tags – small passive radio transmitters attached to components that can be polled by RFID detectors to track their movements.

Purchasing and stock control systems can greatly reduce the overheads and increase the efficiency of traditional stock-keeping systems, resulting in business savings both directly and by enhancing the effects of the rest of the asset management program.

6.2 Purchasing

Purchasing systems provide a mechanism for asset management systems to order spare parts as they are required. Purchasing systems could be simple services that communicate with a business' procurement department, requesting that a purchase order should be raised as parts are required.

More elaborate purchasing systems could be based on Internet technologies such as web services. In these cases, a purchasing system could automatically order parts from suppliers, and route them to the best locations for their storage and use. Advanced systems could even use web-based delivery monitoring systems to track the movements of these parts, and raise alerts when problems arise.

6.3 Automated Scheduling

Automated scheduling systems are designed to respond to the recommendations made by asset monitoring systems and find optimal maintenance schedules that will adequately protect the assets. They can be designed to coordinate maintenance of several assets at once, consult asset usage timetables, and integrate communication systems to inform maintainers of their new plans as they are devised.

The final step in the system is to feed details of work done back into the Asset Register so that it continues to contain an accurate record.

This ensures that servicing is logical and based on need and priority, reducing maintenance costs and making the best use of skilled maintenance personnel.

6.4 Integrated Systems

The real strength of asset management is its ability to integrate with a range of other business processes, streamlining the asset throughout its lifecycle and replacement. If we refer back to the rail network example: rather than recommending servicing to a manager, an integrated management system dynamically updates maintenance plans in real-time, and emails service personnel to inform them of their new schedules. Stock control systems inspect the spare parts reserves, enabling the items needed to repair the track to be moved to a nearby depot in time for the maintenance. Procurement systems automatically communicate with suppliers' systems to replace the stock for these parts, and all of this without any manual intervention.

Suppose, to take another example, a partial blockage develops in an oil pipeline. Unnoticed, the blockage continues to grow. Eventually the increasing pressure in the pipeline causes it to rupture. The entire section needs replacing. Huge costs, financial, environmental, and reputational are incurred. Oil cannot be piped at required rates until manually rerouted. Contrast this with a managed pipeline: Asset monitoring systems detect the change in the pressure profile along the pipe, and determine the location and size of the blockage. Growth rates for the blockage are calculated and pipe-rerouting plans are created. Maintenance is scheduled around other issues and piping timetables. Servicing materials are routed to the nearest service depot, and replacements are ordered automatically. The entire business structure has mobilized to protect critical infrastructure autonomously in a cohesive, systematic way.

7 Building an Asset Monitoring System

A complete asset monitoring system can be a large, many-faceted system. There are, however, rarely built all in one go; indeed some of the information needed to construct the downstream parts of the system may not exist at the outset. The most successful asset monitoring solutions are constructed in stages, learning lessons along the way. The process would typically be:

- Begin data collection
- Build the data analysis system
- Understand how the behaviour of the assets relates to the results of the data analysis
- Introduce a decision support model and possibly a fault model
- Refine the models in the light of how they perform
- Once the models have achieved sufficient reliability, begin using them to schedule maintenance activities automatically
- When the system is sufficiently mature, automated alarms can be implemented
- Adopt a continuous improvement model, improving each stage based on its current levels of success

Of course, no system can eliminate all failures. The key issue is the domain of expertise that the system has – an asset monitoring system can only cope with problems that it has been designed or trained to recognize.

This domain of expertise will be defined during the design process for the system. Whilst systems can be produced that can adapt to certain new scenarios, it is difficult to design a system that handles all possible faults that can occur.

Because of this, asset monitoring should not be seen as a complete replacement for human observation, analysis and decision making. Rather it is a complementary system that can replace the manual monitoring of well-defined problems. Thanks to enhanced data collection and record keeping, understanding of other, rarer problems will increase and in time, their monitoring can be integrated as a routine part of the system. Thus, the usefulness of an asset monitoring system should continue to grow over time.

8 Conclusion

Asset monitoring systems are a powerful tool for protecting critical assets, maximizing their availability, reliability and performance. In short, making the assets work harder, smarter and allowing them to deliver greater value. Asset monitoring can be combined with other technologies to produce an integrated asset management and maintenance system, which complements rather than replaces traditional manual inspection programs.

The effectiveness of any system is rooted in strong design, and this is particularly true of asset monitoring. A well-implemented system can impact every part of an organization, increasing asset uptimes, reducing maintenance costs, increasing profits and enhancing the reputation of the business with its customers.

9 Further reading

If you would like paper or electronic copies of any of the following, please email info@tessella.com

Technical Supplements:

- Decision Support Systems
- TAPAS Condition Monitoring Overview

Case Studies:

- Asset Management for Metronet Rail
- Southern Rail: TAPAS Rolling Stock Condition Monitoring
- Asset Condition Monitoring for Balfour Beatty Rail Technologies

Webcast:

- The Tessella Asset Optimization Toolkit

For more information on Modelling, please visit www.tessella.com/Services/Discipline/modellingandsimulations.htm

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