Integrated Asset Information Management Practices for Water and Wastewater Utilities

Executive Summary ................................................................. 2
The Water and Wastewater Industry ......................................... 3
Asset Management Challenges for Water Utilities ..................... 4
Maintaining Physical Assets Efficiently ................................. 6
Compliance with Asset Management Standards ......................... 9
Integrated Operations, Asset Management, and Engineering ........ 12
Expected Operational Benefits and Impacts on Risk and Efficiency .... 16
Recommendations ..................................................................... 17
References ............................................................................... 18
Executive Summary

Under pressure from consumers and regulators alike to improve water quality and increase supply while protecting water sources, water utility companies must transform the way they develop and maintain water infrastructure. Furthermore, they must do so in an extremely capital-and resource-constrained environment. While this may sound daunting, ARC Advisory Group believes it actually represents an opportunity for the industry.

In existing installations, operations and maintenance, supported by engineering and contractors all work simultaneously on an interconnected set of assets. Process conditions, equipment, and infrastructure change at varying rates and to varying degrees. Operators, maintenance technicians, and engineers all require visibility into up-to-the-minute engineering information, asset state, and asset health to be able to make accurate and timely decisions during operations and maintenance. It also helps ensure up-to-date plant documentation.

This makes it essential to have a central asset information hub accessible to all stakeholders. In addition, water utilities need a solution to support efficient maintenance planning and execution, shutdown, inspection and workforce management; and operational compliance and reporting. Ideally, to support regulatory compliance, the solution would also provide engineering capabilities and a systematic approach to link operational risk assessment to asset requirements and test plans.

Integrating these types of asset information across their asset life cycles can improve asset and compliance management, plant design, engineering and process development. Companies that pioneered this approach have obtained impressive results. Business benefits include reduced operational and safety risk; increased engineering, maintenance, and operations
productivity; faster operational readiness of assets and personnel; and/or more accurate and less costly regulatory compliance.

The Water and Wastewater Industry

Infrastructure to capture and transport water and to discharge wastewater was already present in ancient cultures. This infrastructure ranged from very primitive to highly sophisticated. The Roman Empire, for example, boasted a well-engineered system of aqueducts, cisterns, and even indoor “plumbing.” While water and wastewater infrastructure and related services today are commonly associated with municipalities, they are equally important for industry, agriculture, and transport.

Recognizing that access to clean drinking water and effective wastewater services is an essential human right, the United Nations has set ambitious goals for upgraded water and wastewater infrastructure, particularly in developing countries. While water utilities function as industrial operations, water and society are inseparable. This has many long-term implications for authorities, municipalities, and water services companies.

Water and wastewater utilities alike must comply with the local legal or regulatory requirements and policies. Water and wastewater both also have an important impact on the environment, since over-withdrawal and/or poor wastewater treatment can harm underground aquifers and surface waters, threatening water supply at worst, and requiring increased treatment at best.

Currently, access to limited financial, human, and natural resources tend to be unevenly distributed globally. As a result, water and wastewater utilities must be managed to contribute to sustainable development to help ensure long-term availability of water at affordable prices, while preserving health and environment.

The often-deteriorating urban water infrastructure struggles to keep up with increasing demands and, in many cases, rural infrastructure is non-existent. This is particularly true in poorer world regions. Available finan-
cial resources are often used for expansion, causing the older parts of the assets to suffer from a lack of maintenance and modernization. This makes it a real challenge to invest carefully and maintain physical water utility assets efficiently over their long life cycles.

**Asset Management Challenges for Water Utilities**

In many utilities, asset information is spread over a multitude of software applications, databases, and paper files and often not updated or synchronized as frequently as needed by internal personnel and outside contractors. As a result, the asset information available to operations, maintenance, and engineering staffs is often inaccurate, out-of-date and/or inconsistent. This “information erosion” creates challenges and inefficiencies, further burdening an often already overstretched workforce. For example:

- When engineering or maintenance groups troubleshoot an operational issue or need to start a modification project, they must first spend time – sometimes days or weeks – determining the actual configuration, status, and performance of the equipment, piping, availability of spare parts, etc., before being able to start performing any actual work.
- Further time is lost ordering missing parts or equipment, increasing time to repair.
- In other cases, excess spare parts are available, tying up working capital without delivering any benefit.

Incomplete, inaccessible, and/or inaccurate asset information increases project duration, mean times to repair (MTTR), and both operational and capital expenditures.

Water utility assets are, by nature, distributed. Wells, reservoirs, pump stations, piping networks, treatment plants, and other infrastructure and assets are spread over large geographical areas.
Often, the owners of the installations are municipalities that outsource the operations and maintenance of their assets to industrial water services companies. Increasing pressure to improve performance and sustain assets while containing costs drive the need to manage assets effectively and more efficiently. Contract durations become shorter, requiring operating companies to be able to add and withdraw managed assets in an efficient manner. The flexibility to carve out information related to asset sections, or add asset information quickly is important. These challenges make it a non-trivial task to obtain a complete, accurate, and up-to-date virtual image of the distributed assets for central office personnel, in-plant operators and maintenance staffs, and field workers.

In addition, regulatory pressures are increasing and will continue to do so in the future. Federal, national, or state regulations require regular reporting on the quality of water and concentrations of contaminants. Water utilities must be able to report quickly about water quality deviations and demonstrate that appropriate corrective actions have or can be taken.

Safety-related regulations such as IEC 61508 and IEC 61511 are also becoming more demanding. Increasingly, the spirit of these regulations is moving toward requiring the owner-operator to be able to demonstrate performance-based, quantitative risk management.

ISO standards for water and waste water services (ISO 24510, 24511 and 24512) and asset management (ISO 55000, 55001 and 55002) are currently only recommendations and not enforced by regulation. However, their usage provides considerable benefits and can help owner-operators maximize the benefits received from their technology investments. Upcoming
standards such as DIN SPEC 91303 will help owner-operators model asset data, injecting quality and efficiency into the process.

## Maintaining Physical Assets Efficiently

Asset management systems based on ISO standards and supported by an asset information management software application can help water utilities overcome many asset maintenance and compliance challenges, including organizational-, process-, and management-related challenges. Ideally, such an application should be capable of supporting operations and maintenance, include project engineering capabilities, and be able to model existing and new complex assets in a structured way. The model must include all assets: buildings, piping, process equipment, electrical equipment, automation and instrumentation, and so on. The application should also be able to manage and link asset data to diverse asset-related documents, including Microsoft Excel spreadsheets, PDF files, or 3D design files.

It is one thing to model an existing or newly built installation, but asset information is most valuable when the digital image of the assets is kept up to date; when it reflects the actual asset state at any given time. Ideally, processes should be in place to update asset information when any significant maintenance activity or modifications are performed. Therefore the data must be easy to maintain by all staff and adaptable to equipment changes, extensions, or replacement.

Up-to-date asset information enables accurate planning for maintenance and inspections. An asset information solution must take the equipment status into account and, ideally, be able to use real-time plant and equipment data to plan maintenance and inspection schedules, and be “aware” of equipment warranty information and status and instrumentation calibration records. When maintenance is overdue, the software application should be able to escalate to the next level of responsibility. It must also support diverse maintenance strategies, including reactive, condition-based and predictive maintenance.

Advanced maintenance strategies rely on real-time asset information and status. Integration between the asset information system and the process automation systems reduces the effort required to implement these strategies. Further integration with other applications in the operations management domain (historians, performance dashboards, process simula-
Common Software Application Supports Engineering, Operations, and Maintenance

COMOS is Siemens’ software solution for plant engineering and operations in the process industries. It supports maintenance planning, execution, and analysis of multiple maintenance scenarios. Inspection tasks management as well as mobile device and shop floor applications for field personnel are part of the integrated offering.

COMOS provides all stakeholders with instant, transparent access to information related to a plant object, enabling different disciplines and roles in maintenance and operations to collaborate in a structured manner.

As a result:

- Engineers and field engineers have direct access to information changed by colleagues in other disciplines.
- Better maintenance-related decisions and activities and improve asset reliability while reducing cost.
- The time needed to find information is reduced substantially, leading to productivity improvements and more effective responses to emergencies.
- Configurable workflows enable compliant, quality-controlled processes, projects, and document generation.
- Plant documentation is kept up-to-date to meet regulatory obligations.

For maintenance activities and small improvement projects related to automation and instrumentation, integration between the asset information system and the automation systems simplify the changes to the automation systems and enable the control systems to be configured based on the engineering design, and vice versa. When a control system configuration is changed in the field, the asset information application would automatically be updated with the actual control system configuration. Depending on the organizational structure, engineering, maintenance, and/or operations personnel may collaborate during these activities. It is critical that stakeholders work off the same, up-to-date asset and engineering data. As we’ll discuss in more detail later in this report, this is sometimes referred to as “integrated engineering,” “integrated operations,” or “integrated asset information management.”

Planning and assigning activities to maintenance teams must be in-line with their qualifications, respect HSE policies and regulations (such as required rest periods and vacation schedules), and account for the relative travel distances to remote sites. In the field, personnel should be able to use portable handheld devices with RFID or barcode scanning capabilities to guide them through protocols and standard operating procedures, check off items on work lists, and/or report changes made, materials consumed, or equipment replaced. The application must interface with ERP for placing MRO
spare parts orders and reporting time, placed equipment, and consumed materials.

The application should be able to support planning and execution of shutdowns, revamps, or decommissioning activities. This should include planning for staff and resources; scheduling activities and generating work instructions; reporting on progress against time, cost and quality goals; and providing “as-built” documentation of the turnaround.

The application must be “validation-ready” if required by local regulation. This typically requires the ability to support electronic signatures and audit trails. It should support qualification or validation processes; include proper work instructions for any type of equipment; enable use of configurable, compliant protocols; and be capable of creating declarations of conformity. More and more, regulations require operating companies to produce up-to-date documentation of installations within increasingly shorter time periods, sometimes hours. An electronically up-to-date asset information hub is often the only way a company can comply with this requirement.

It goes without saying that all functionalities described above, whether in the operations, maintenance, supply chain, HSE, risk management, compliance, project or portfolio management domains, rely on a seamless interface with an ERP application.

When the rare emergency occurs, operators in water utilities today are not always prepared to act appropriately when water quality or quantities deteriorate at the source, during processing, or during transport. When decisions have to be made quickly, accurate up-to-date information is critical to reduce or limit damage. Wrong or outdated information can cause precious time to be lost or damage to increase. Once again, an up-to-date electronic “as-maintained” image of the installation can be invaluable here.

Because assets are distributed geographically, field personnel tend to work in isolation. Engineering and support centers tend to become more centralized, increasing risk of a culture divide and reduced exchanges between maintenance and engineering. Collaboration of engineering and asset information using common tools and processes is important to improve mutual understanding and reduce the perception of isolation. Improved information exchange among teams decreases the opportunity for friction to develop.
Finally, complying with regulations and standards can involve considerable cost for organizations. Compliance management can become more efficient when supported by engineering and asset information management applications with configurable workflows, such as Siemens’ COMOS software solution for asset information management.

**Compliance with Asset Management Standards**

Good asset management is now becoming a standard practice in mature organizations around the world. The formal documentation of good practices for managing physical assets has been led by the British national standards body, BSI, in cooperation with the Institute of Asset Management (IAM) and close to fifty organizations from fifteen industries in ten countries. The resulting PAS 55 standard was published in 2004 and revised in 2008. It has been widely adopted and become the basis of the ISO 55000 standard. The important themes in the standard include:

- Asset management strategies, objectives, plans, and day-to-day activities, should all be aligned with organizational objectives
- Focus on lifecycle asset management planning and cross-disciplinary collaboration to achieve the best value combined outcome
- Focus on risk management and risk-based decision-making

The standard can serve as an enabler for integration and sustainability; particularly leadership, consultation, communication, competency development, and information management, as well as for quality control and continuous improvement.

The standard also defines requirements for audit and documented information and refers to other ISO standards for specific aspects. For risk management and management of water utilities, the standard refers to the ISO 31000 and ISO 24510 standards, respectively. The standard spells out the general principles for good management and governance of the asset management systems and processes. However, it leaves it up to the owner-operator to decide how and at which level of detail to implement the standard.
The benefits of good asset management practices documented by Woodhouse at AIM include significantly reduced downtime, reduced production costs, reduced total cost of ownership of assets, increased throughput and reduced maintenance costs, and increased output; all achievable with no incremental cost. Once again, software applications such as COMOS that provide centralized access to asset information can support the implementation of such a system.

As mentioned above, an effort is under way in Germany to specify how asset information can be modeled to define the requirements for asset information attributes. While this standard is not available yet, we anticipate that an international equivalent will be published, probably focused on industrial asset information and complimentary to the ISO 55000 standard.
Linking Asset Information with Risk and Compliance Management

In addition to ISO 55000, we’re seeing increased concern about functional safety regulations and standards such as IEC 61508 and 61511 in many industries. To support functional safety compliance, asset characteristics, design methodologies, regular inspection schemes, and so on can be managed efficiently in the same software environment used for integrated engineering and operations.

Systems Engineering Approach for Integrated Asset Information and Compliance Management Requires Project and Workflow Support

Analysis of risks related to the process and the equipment on the product quality and equipment reliability can be systematically derived from asset information and partially automated by the asset information management tool. The results of the analysis must be reflected in appropriate requirement specifications and designs. Once the design is finalized, testing and qualification plans can be derived automatically from the engineering in-
formation. Test and qualification results can be linked back to equipment requirements and the risk analysis for validation purposes.

For operating installations, risks must be managed continuously, in successive loops of assessment, improvement, and mitigation. To generate conformity certificates electronically for renewed compliance, COMOS MRO enables users to create a risk matrix for equipment and processes, risk-based inspection, and reliability-centered maintenance.

**Integrated Operations, Asset Management, and Engineering**

Asset information is generated during both the engineering & construction and the operations & maintenance phases. Once the asset is operational, engineers, operators, and maintenance technicians often all have to work on the same asset; ideally using the same consistent and up-to-date asset information to perform engineering design changes and improvements; operations and maintenance for day-to-day activities; and long term asset management. As previously discussed, this can be even more challenging with when engineering and/or construction is done by a third party.

In 2005, Dr. Thomas Tauchnitz published a vision for integrated engineering based on three basic principles: 1) all information is generated and maintained at only one location; 2) existing knowledge is reused where possible, and 3) the software tools stay interfaced while the production plant is in operation.

He sketched the workflow starting with process design followed by the transfer of the resulting process information to a common engineering software tool used for front-end and detail engineering. To increase engineering efficiency, he proposed to implement modular engineering using standardized, generic engineering modules that comprise all functions built and maintained within the common tool. Since all disciplines have access to the same up-to-date information and use the same engineering tool, collaboration is improved and errors and iterations minimized.

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**Tauchnitz’ Principles for Computer-Integrated Production and Engineering:**

- All information is generated and maintained at a single location
- Existing knowledge is reused where possible
- The system remains in use while the plant is in operation
Many plants that are otherwise similar in nature can have a wide variety of different control systems installed. To increase engineering efficiency, control engineering should be done at a generic level, enabling reuse of designs and configurations. Generic designs could be used to configure different system types when compiled within these systems. The next step is to transfer the engineering information to operations and maintenance and keep it up to date to transform “as-built” information into accurate “as-maintained” information. This is can be accomplish seamlessly and with minimum effort when all parties use the same application. This, of course, assumes that the application can handle the requirements and functionalities for operations and maintenance as well as engineering.

“Integrated engineering” integrates different disciplines during design and build stages and also integrates automation, operations, and maintenance information during all stages of the installation’s life cycle.

Finally, the vision includes implementing standardized processes across the extended enterprise, reducing the number of systems and interfaces, and organizing centralized maintenance and support and promoting company-wide knowledge management.

**Implementation and Application**

Today, companies across a variety of process industries use the COMOS software solution to implement the vision of integrated engineering and operations. The solution’s centralized, object-oriented database in conjunction with engineering and user libraries and collaborative workflow
Benefits of Integrated Engineering and Operations

Usage of a single, consistent and up-to-date database for design, engineering, construction, handover, operations and maintenance can help increase productivity, shorten project time, accelerate operational readiness, and improve regulatory compliance.

modeling helps enable this. While most companies and their subcontractors do their engineering work with computer-aided design software, when an installation is commissioned, documentation is still often handed over on paper. All too often, this handover is not performed in a timely manner and the documentation provided may be incomplete or already out-of-date. As a result, critical engineering and configuration information is lost that could otherwise provide the owner-operator with significant value for operations and maintenance.

With paper documents for operations and maintenance, changes are documented as hand-written corrections, often referred to as “redlining.” In the best case, electronic documents are updated afterwards. This process is both time consuming and error prone, information is often out of date, and interactions between disciplines lead to unnecessary iterations.

Many engineering databases and systems do not have the functionality to support operations and maintenance (and vice versa). As a result, a maintenance management system must be primed with “as-built” information extracted from the handover documents. When the company needs to modify, maintain, or modernize a plant or production line; plant personnel often have to start by tediously searching for and integrating both “as-built” and “as-maintained” data to be able to create an accurate electronic image of the installation, the “digital twin.” This enables any operator, engineer, or maintenance technician to access the needed up-to-date static or dynamic asset information from his desk or even from a handheld device in the field.

For maintenance and improvement projects related to process equipment, automation, and instrumentation; bi-directional integration with automation systems enables the control system to be configured directly from the design in the engineering tool, saving time and reducing the opportunity for errors. Vice versa, when a control system configuration or equipment characteristic is changed in the field, the control system would automatically update the application with the actual control system configuration. Collaboration between internal or external engineering departments and maintenance (and/or operations) may occur during these projects or changes. It is of utmost importance that the stakeholders work off the same, up-to-date asset and engineering data.
For engineering and modernization projects, this can simplify the work and unload personnel, while helping guarantee accurate and up-to-date asset information. It creates even more benefits by saving engineering work when the same change needs to be applied to several sites. Siemens now offers an operational bidirectional interface between COMOS and SIMATIC PCS 7. To the best of our knowledge, this is the first and currently the only full-scope implementation of the recent NAMUR NE 150 standard. It paves the way for potentially enormous future efficiency gains in control engineering and maintenance.

With its extended capabilities for engineering, as well as maintenance and vertical integration with enterprise resource planning (ERP) systems and control systems, integrated engineering is now a feasible target.

A recent case study, involving the worldwide rollout of COMOS at the pharmaceutical company, Novartis, demonstrated that the integrated engineering vision implemented in this type of application can be applied successfully to both brownfield and greenfield projects for engineering, operations, and maintenance. Novartis decided not only to have all new asset information in electronic form, but also to transfer over time all existing paper documentation into COMOS. Today, Novartis estimates that this helped reduce ongoing engineering effort by 10 to 15 percent. ARC believes that this type of integrated operations solution could deliver similar benefits for asset-intensive water utility companies.

Since modular engineering techniques and integrated, cross-discipline engineering practices affect people’s work processes and practices, successful implementation also requires careful change management planning, including user participation and continued management coaching and support.
Expected Operational Benefits and Impacts on Risk and Efficiency

When kept up to date, the use of a single, consistent and global data hub such as COMOS by all disciplines helps create instantaneous and complete transparency of information for each plant object and all parties. Engineering and asset information handed over to operations from the project team can be kept up-to-date and exploited to help troubleshoot operations and support both routine maintenance and more involved activities, such as replacing or repairing equipment, capacity expansions, or modernizing automation and instrumentation.

Adding predictive maintenance approaches could provide additional benefits. These may combine condition monitoring and reliability solutions interfaced through the control system to predict impending issues for remediation by maintenance and, in some cases, even predict remaining useful equipment life. This information is directly available in COMOS to support maintenance and/or asset replacement planning.

Expected gains that directly impact operational and maintenance costs include reduced effort, reduced spare parts, and significantly shortened project times, plus reduced cost and effort for complying with requirements for up-to-date plant documentation. Furthermore, faster and more appropriate responses to operational issues can help reduce unplanned downtime, mean time to repair (MTTR), and operational risks. Improved reliability and asset longevity can both help reduce capital expenditures.

Engineering Benefits

Based on validated business cases in other sectors, Siemens believes that it’s realistic to expect that appropriate use of COMOS can provide engineering productivity or efficiency gains of at least 5 percent. Regulatory compliance costs could also be decreased by integrating e-compliance approaches with engineering and maintenance. EPC (engineering, procurement, and construction) firms could also derive a competitive advantage from using the software.

Can reduced engineering effort help compress project schedules to reduce “time to operational readiness?” According to many of the end users and EPCs that ARC has interviewed on this subject, the answer is “yes” for many companies that perform project engineering work sequentially.
However, companies with major time constraints often perform a significant amount of engineering work in parallel. To compensate for the iterations and rework often related to parallel engineering approaches, the companies employ additional resources. These companies will experience less compression of the engineering and scale-up phases. However, they could potentially experience a higher-than-average impact on total engineering efficiency. This is because they would recover part of the non-productive iterations and effort by using an integrated engineering methodology and a common engineering repository such as COMOS.

Based on our research, ARC believes that the integrated engineering approach discussed in this report could realistically yield at least a 5 percent improvement in engineering efficiency. Some companies have remarked that can increase engineering efficiencies incrementally by a few percent each and every year through good engineering practices and tools.

**Recommendations**

ARC Advisory Group has the following general recommendations for water utility companies:

- Before implementing asset management practices in a software application, optimize and improve these practices using recommended guidelines provided in international standards such as PAS 55 and ISO 55000. Once implemented, make sure changes to installations are consistently documented in the application.

- Apply the concept of integrated engineering and integrated operations. Follow Novartis’ example and implement paperless processes and documentation consistently.

- Analyze process development and plant engineering, operations and maintenance processes, including information processes. Define global medium-term goals and evaluate processes and their results. Optimize both the manufacturing processes and supporting IT landscape and re-evaluate. Make a business case to quantify the incremental benefits.

- Make sure organizational units are aligned in terms of goals, incentives are consistent, and common processes understood and agreed upon.
When implementing change, make sure the culture change aspect is given the time and attention required for sustainable improvement.

- Create oversight and monitor, evaluate, support, benchmark, and continuously improve processes and applications globally through governance and/or corporate excellence initiatives.

- Promote usage of the NE 150 standard to create additional benefits related to control system engineering, maintenance, and modifications.

**References**

ISO 24510, “Activities relating to drinking water and wastewater services - Guidelines for the assessment and for the improvement of the service to users”, Reference number ISO 24510:2007.


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Acronym Reference: For a complete list of industry acronyms, refer to our web page at www.arcweb.com/Research/IndustryTerms/

AIM  Asset Information Management
BSI  British Standards Institution
DCS  Distributed Control System
EPC  Engineering Procurement and Construction
ERP  Enterprise Resource Planning
HSE  Health, Safety and Environment
ISO  International Standards Organization
IT   Information Technology
MES  Manufacturing Execution System
MRO  Maintenance, Repair and Overhaul
PAS  Publically Available Specification
R&D  Research and Development
RFID  Radio Frequency Identification

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