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NALAS

Municipal Asset Management Toolkit

(Guidelines for Local Decision Makers)

November, 2014

FACT SHEET

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Network of Associations
of Local Authorities
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ABBRAVATIONS

SEE	South Eastern Europe
PUC	Public Utility Company
AM	Asset Management
WS	Water Supply
WW	Waste Water
O&M	Operation and Maintenance
LOS	Level of Service
ISO	International Organization for Standardization
GIS	Geographical Information System
SCADA	Supervisory Control And Data Acquisition
CAD	Computer Aided Design
RDBMS	Relational Database Management System
ERP	Enterprise Resource Planning
CIS	Customer Information System
CMMS	Computerized Maintenance Management System
CRM	Customer Relationship Management
EMS	Engineered Management Systems
CPMS	Capital Program Management Software

1 INTRODUCTION

1.1 WHAT IS ASSET MANAGEMENT?

Asset management is an integrated approach to monitoring, operating, maintaining, upgrading, and disposing of assets cost-effectively, while maintaining a desired level of service. It may apply to both physical assets, such as buildings and equipment, and non-physical assets, such as intellectual property. Asset management applies to industries as diverse as transportation, electric power, manufacturing, public service companies and many others.

Asset management implies a set of practices intended for decision-makers and operators to improve decision-making process thus improving the overall business performance.

The core of asset management includes processes or activities addressing a proactive management of infrastructure assets, instead of reactive, as follows:

- Maintaining a systematic record of individual assets (an inventory) with regard to acquisition costs, original and remaining useful life, physical condition, and cost history for repair and maintenance;
- Having a defined programme for sustaining the aggregate body of assets through planned maintenance, repair, and/or replacement;
- Implementing and managing information systems in support of these elements.

These processes are interrelated and in some cases interdependent. The Figure 1 illustrates and input/output model of an asset management system showing a general relationships among all the elements.

1.2 OBJECTIVES OF ASSET MANAGEMENT

The primarily objective of asset management is to assist organizations in meeting a required level of service in the most cost-effective way, thus ensuring a long-term sustainability of any organization or company, including public utilities.

1.3 HOW DOES ASSET MANAGEMENT WORK?

This document deals specifically with management of physical assets in public utility companies, referred to as *infrastructure asset management*.

The basic premise of infrastructure asset management is to intervene at strategic points in an asset's normal life cycle to extend the expected service life, and thereby maintain its performance. Normally, an asset tends to run at a fairly level condition state for a majority of its life. After a number of years, this relatively stable period is followed by degradation of asset's condition at an increasing rate as asset's components wear out. This causes degradation of asset's performance and increases the operating costs significantly. To avoid this from happening, a long-life-cycle asset requires multiple intervention points including a combination of repair, preventive and/or predictive maintenance activities, and even overall rehabilitation. This means to spend money to improve physical condition and improve performance with the objective of extending service life. The longer service life can be extended before the asset has to be completely replaced, the more economical is the overall performance. Costs decrease with planned maintenance rather than unplanned maintenance. Yet, excessive planned maintenance increases costs. Thus, a balance between the two must be recognized.

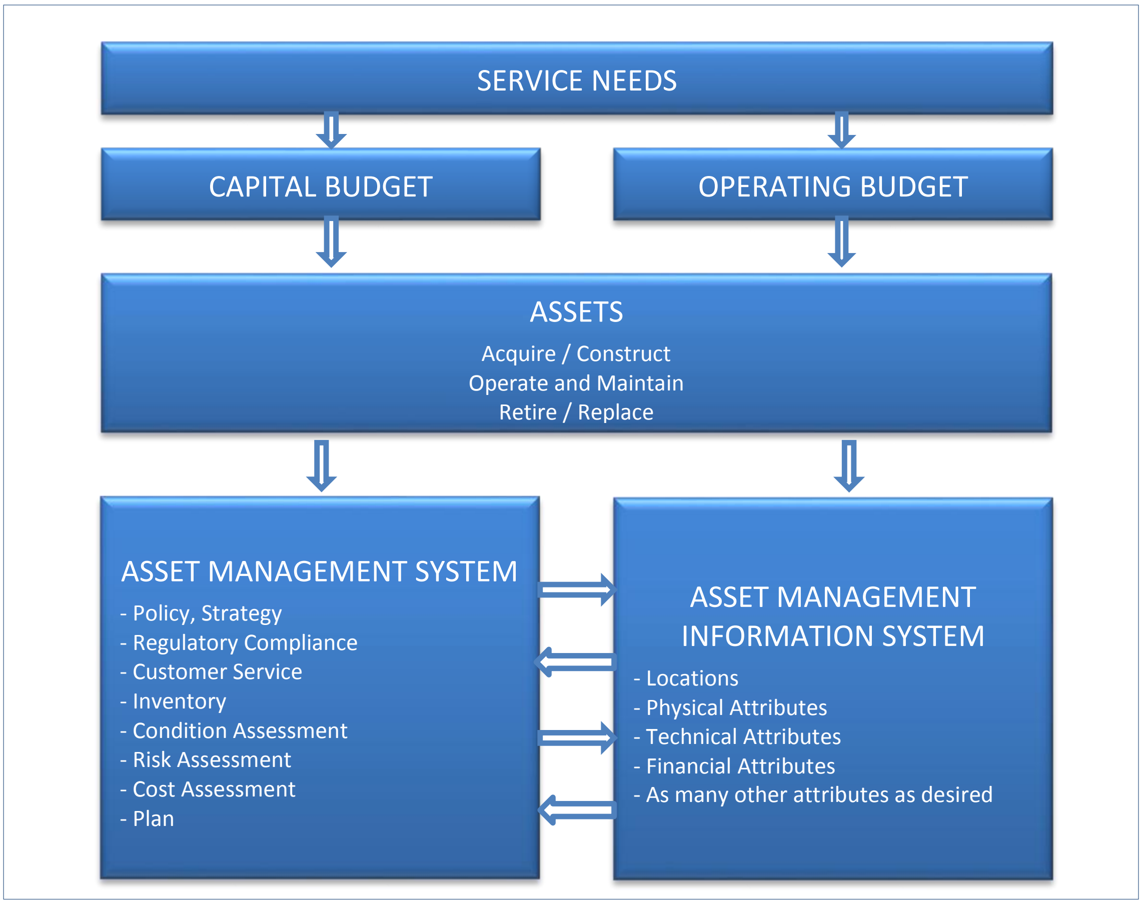

Figure 1: Asset Management Model

An asset or system of assets having a very long life cycle may require a combination of repair and maintenance activities followed by an overall rehabilitation. This cycle could occur multiple times over the course of asset service life before complete replacement is necessary. Each condition improvement raises the asset to a higher level on its condition curve. Each rehabilitation resets the condition curve, although perhaps not to as high level as the original new asset or a complete replacement. By employing strategically timed investment, the net effect of these activities is to keep elevating the condition curve, thereby extending the overall asset life cycle.

The strategic points for intervention in the asset condition are before degradation has reached a point that it is more economical to replace then to rehabilitate. Identifying these strategic points requires experience and professional judgment. Equally important is the availability of reliable data on asset condition, historical costs of repair and maintenance, and estimated costs of rehabilitation.

1.4 THE PURPOSE OF THIS TOOLKIT

This toolkit in intended for local decision-makers, both in Municipalities and Public Utility Companies, who should act together in using the toolkit, reconciling their differences and interests and focusing on what is best for the community regarding provision of public utility services.
The purpose of the toolkit is introducing decision-makers with the systematic approach to management of public utility assets (water and wastewater assets), as well as providing the guidance on implementation of asset management practices.
The use of this toolkit should assist decision-makers in the following:

- Recognition of advantages of integrated systematic approach to management of public utility assets,
- Establishing a better organizational structure and designation of responsibilities in managing public utility assets,
- Gradually introducing asset management practices as part of everyday activities.

The aim of the toolkit is to provide utility asset management practitioners, policy and decision-makers basic information and knowledge to help them implement the most fundamental aspects of asset management. The toolkit should enable readers to identify gaps or challenges, and draw up a strategy for addressing these challenges using information and other resources assembled for this purpose.

1.5 HOW TO USE THIS TOOLKIT

This toolkit is a practical guide consisting of useful approaches to effective management of municipal public utility assets. It should be implemented step-by-step following a top-down approach.
The starting point should be a clear assignment of roles and responsibilities between local governments (Municipalities), on one side, and Public Utility Companies, on the other side, as well as assignment of tasks within staff of both local actors.
Statement of the AM policy and development of AM strategy should be the following step undertaken by a senior level staff. Precondition for development of AM plan is collection of asset data and information, as well as application of other asset management techniques to the extent possible at the present time. This step is carried our primarily at the level of utility companies, but monitored by the Municipality. Important role of Municipality, at this point, would be the assessment of available funding for the implementation of activities proposed by AM plan.

2 CONCEPTUAL FRAMEWORK FOR ASSET MANAGEMENT

2.1 THE NEED FOR AN ASSET MANAGEMENT SYSTEM

In SEE countries, public utility assets are managed, and sometimes owned, by PUs, but the PUs are owned by local government (Municipality). Management of all aspects of providing water supply and wastewater services is deeply influenced by the municipal authorities, which are responsible for monitoring activities of PUs, approving their business plans and reports, service tariffs, etc. Local authorities sometimes provide grants for capital investments in utility infrastructure, but usually capital investments are the responsibility of PUs, as this is clearly stated in most of the respective local decisions/decrees. However, PUs usually lack financial resources even for regular maintenance, not to mention for bigger investments. The current practice in managing public utility infrastructure has, obviously, not been satisfying as it resulted in many problems that both Municipality and PU face nowadays, such as: (i) old infrastructure, which has not been rehabilitated in due time to prevent serious deterioration; (ii) frequent failures due to poor maintenance; (iii) high water losses; and finally (iv) technically, financially and organisationally inefficient system.

Local decision-makers should care about managing public utility assets in a cost effective manner for several reasons: 1) these types of assets represent a major public investment; 2) well - run infrastructure is important in economic development; 3) proper operation and maintenance of a utility is essential for public health and safety; 4) utility assets provide an essential customer service; and 5) asset management promotes efficiency and innovation in the operation of the system.

The most important trigger for implementation of asset management practices in public utility is the concern about aging physical assets. If the required annual maintenance is not performed to the extent necessary (which is usually 2% of its investment value annually), as well as periodic upgrade of assets (capital investments) is not performed at strategic points, the assets will deteriorate significantly. Costs of operation and maintenance will also increase as the assets age, burdening PUCs, even more, with excessive costs that it can no longer afford. Normally PUCs do not have enough financial resources to rehabilitate or replace all deteriorated assets at once, and therefore, are in need of a strategic and integrated approach which provides answers on how to prioritize among investments/interventions and make better decisions.

A specific situation in public utilities is the lack of basic data on characteristics and location of assets (buried assets), as these data are often known only by an aging/retiring workforce, and it is necessary to transfer their knowledge into asset records/inventory.

Another trigger is unreliable network/system that is subject to frequent failures, making it difficult to deliver the type of service that customers expect and demand. Consequences of asset failure may be broader then interruptions in service delivery, including environmental, economic and health consequences.

Finally, there is usually no long term planning of capital investments based on balancing risks and consequences of asset failure with costs of investments. As the result, scarce financial resources, both municipal and PUC's, are spent on non-prioritized investments instead on investments that contribute more to the improvement of systems' efficiency in meeting the required level of service, and to the improvement of business effectiveness of PUC. Planned maintenance and timely upgrade of the system allows focus on those interventions/investments that provide improved service at reasonable costs.

All of these crucial issues are dealt with by various elements of Asset Management System.

2.2 REGULATORY FRAMEWORK FOR ASSET MANAGEMENT

Water and sanitation services in SEE countries are usually regulated by relevant decisions/ordinances which establish the basic elements of these services as well as responsibilities of service providers - Public Utilities. These decisions regulate the type of utility services, conditions of drinking water supply, discharge of urban waste water into the recipient via the sewerage system, connection to water supply and sewerage systems, the relations between the service provider and the service user, etc. This aspect in most countries is regulated by municipal regulations, but is some countries by state regulations. These regulations usually contain provisions that the PUs are obliged to provide continuous and undisturbed utility services to all customers, to maintain good condition and functionality of utility assets, to maintain health and hygiene standards, etc. But there is a lack of provisions on the methodology or a system for achieving aforementioned requirements.

Governments of some countries with the high level of implementation of asset management in water utilities, such as Australia and New Zeeland, have strongly endorsed the concept of asset management. The legislation in these countries has called for water utilities to improve their financial management and to recover the full cost of service. In the UK, utilities must have asset management plans that identify the level of investment required to maintain and improve capital assets every five years. Legislation in Portugal has prescribed obligatory asset management in water utilities as well.

National/municipal governments in SEE countries should also consider endorsing the requirements of asset management in respective legal/regulatory acts.

2.3 APPROACH

Asset management is a quite new approach being developed in the world in the last decade or so. The leading countries in implementing asset management are New Zeeland, Australia and Canada, whereas in Europe – United Kingdom and Portugal.

Among the literature available on asset management, one can find some different approaches to this issue.

In 2008, the Institute of Asset Management from UK has developed guidelines for implementation of asset management, called PAS 55[1]. It provides description of 28 aspects of good asset management practices, from lifecycle strategy to everyday maintenance

[1] The Institute of Asset Management, PAS 55-1:2008, Part 1: Specification for the optimized management of physical assets, 2008

(cost/risk/performance). The PAS 55 was a basis for development of a standard ISO 55000 which was published in January 2014. According to PAS, all aspects of asset management are integrated in the overall, so called, asset management system. This approach is applicable for all industries which base their business of assets, not just public utilities.

AWARE-P methodology[2] is an innovative infrastructure asset management planning methodology intended specifically for implementation in water utilities. It was developed by mostly Portuguese experts within AWARE-P project. This approach implies three planning decisional levels: a strategic level, driven by corporate and long-term views and aimed at establishing and communicating strategic priorities to staff and citizens; a tactical level, where the intermediate managers in charge of the infrastructures need to select what the best medium-term intervention solutions are; and an operational level, where the short-term actions are planned and implemented. This approach implies that planning future interventions includes assessment and comparison of intervention alternatives from the performance, cost and risk perspectives over the analysis horizon. The required knowledge competence for making such decisions is threefold: business management, engineering and information.

The approach used in this toolkit will be a combination of available approaches, by simplifying the requirements and the level of detail of an asset management system.

[2] Helena Alegre and Sérgio T. Coelho, Infrastructure Asset Management of Urban Water Systems, IWA Publishing, 2013

2.4 STRUCTURE OF AN ASSET MANAGEMENT SYSTEM

Asset management system is a set of elements / practices that are used by respective decision-makers (Municipality, Public Utility Company) seeking to implement asset management. The first step in practicing asset management is defining a scope of AM system.

AM system recommended by this toolkit should consist of the following elements:

- Asset management policy,
- Asset management strategy and objectives,
- Asset management plan,
- Asset management human factors,
- Asset management techniques,
- Asset management monitoring and improvement,
- Asset information management.

2.5 PLANNING AND IMPLEMENTATION ELEMENTS OF AN ASSET MANAGEMENT SYSTEM

2.5.1 Asset management policy

As the starting point in implementing asset management, decision-makers need to make a clear statement which implies changing the existing routine and reactive culture of dealing with problems in public utilities into a proactive culture of forecasting the events and planning the activities.

The policy refers to stating several commitments, of both decision-makers, that are most relevant to the provision of utility services. The policy statements should be: i) customer focused, including present and future customers, ii) forward looking, related to future challenges, iii) service focused, iv) risk-based, v) value-based, vi) holistic, vii) systematic, and viii) innovative. The policy should also contain a brief description of tools and methods of achieving defined commitments/outcomes.

The AM policy should be:

- In accordance with the legal requirements for provision on public utility services,
- In accordance with the existing and expected customers' demand,
- Commonly agreed among representatives of Municipality and Public Utility,
- Adopted by relevant municipal and PUC's bodies for a specified long-term period,
- Periodically reviewed by appointed representatives of both Municipality and PUC.

The purpose of AM policy is to establish a clear direction in which decision-makers want to go in planning future activities regarding provision of utility services.

2.5.2 Asset management strategy, objectives and plans

2.5.2.1 AM strategy and objectives

The asset management strategy is a high level but very important document that guides the overall asset management activities within organisations (Municipality and PUC). Being a strategy it is meant to explore long term strategic issues and should look out at least 20 years.

This document should set out how the AM policy will be achieved throughout the business activities. The AM strategy should be aligned with the municipal strategic development goals, the ones referring to water and wastewater sector.

The strategy starts with the "vision, the goals and objectives" and describes how, in practical terms, these strategic objectives can be achieved (generally in the longer term). The strategy covers macro activities and leaves the detailed (micro) activities to the more specific plans.

The AM strategy should incorporate, at least, the following elements:

- Documenting the current status of asset data and defining the future requirements of asset data;
- Defining a required level of service (LOS) that has to be provided to the customers, as all other business activities serve the purpose of achieving this level of service. The required level of service has to balance legal requirements, customers' expectations with asset's risk, affordability and timing constraints;
- Overview of major problems in providing the required level of service;
- Defining strategic asset management objectives;
- Defining the necessary asset management protocols, which will provide guidance to all involved parties in implementing specific practices within the asset management system, such as:
    - Asset data collection and hierarchy protocol,
    - Condition and performance assessment protocol,
    - Criticality/risk assessment protocol,
    - Response to service interruptions protocol
    - Response to customers' complaints protocol,
    - etc.
- Developing requirements for human resources, asset management knowledge and staff competencies;
- Defining roles and responsibilities of both decision-makers (Municipality and PUC) within the asset management system;
- Adopting condition and performance assessment of assets as precondition for making all asset management decisions;
- Adopting a risk-based decision-making processes for prioritization of maintenance and capital investment actions/interventions;
- Adopting lifecycle costing when evaluating competing asset investment needs across utility assets;
- Defining monitoring of the effectiveness of AM practices with a view to continuous improvement.

The AM strategy should be developed jointly by both local decision-makers. When defining a vision and strategic goals and objectives, decision-makers should consider applying participatory planning approach by including customers' opinion and expectations regarding level of service. Once the decision-makers understand what customers expect, they can plan how to manage the asset infrastructure to meet service requirements. Based on customer requirements, appropriate asset and non-asset objectives should be formulated in AM strategy.

Am objectives should be as SMART as possible: Specific, Measurable, Achievable, Realistic, and Time-based. The objectives may take a form of specific asset performance and condition targets such as:

- Legislative and regulatory requirements;
- Service standards, level of service, service output quantity and quality;
- Reliability and functionality of the WS and WW systems;
- Customer satisfaction;
- Safety and environment impact;
- Etc.

AM objectives need to demonstrate commitment of decision-makers to continuous improvement in provision of utility services.

2.5.2.2 AM plan

The detailed AM plan should describe the outcomes (and timing) that result in meeting key strategic objectives. The detailed plan includes operational plans with medium term timeframes (e.g. five year plan). AM plan is described in more detail in Chapter 2.5.

2.5.3 Asset management human factors

Human factors constitute a part of asset management system that enables implementation of all other asset management practices. Human factors include: clear assignment of roles and responsibilities for the implementation of respective tasks, definition of required knowledge and competence of staff, and understanding a need for training.

The premise of successful of asset management is that all parties involved in the process have sufficient amount of information and knowledge about asset management and its requirements.

2.5.3.1 Roles and responsibilities

Both decision-makers who are responsible for provision of public utility services (Municipality and PUC) have to be committed to the development and implementation of asset management system. Each party has to have a clear understanding of the responsibilities they are committed to in implementing asset management. It is required to have a written agreement between Municipality and PUC prescribing their respective roles and responsibilities.

Municipality should normally take a part of a regulator, controller and, to a certain point, implementer of asset management practices. Namely, the role of Municipality should be especially important in developing AM Policy and AM Strategy, where Municipality can establish basic requirements for other AM practices that are to be carried out by PUC.

Major role of PUC is applying asset management techniques and development of AM plan.

When starting to implement asset management it is crucial to establish a clear accountability for asset management at top level. Both decision-makers should designate person/persons who will be Asset Managers in their organizations, responsible for all aspects of implementation of asset management system. Asset Managers should ensure that all adequate resources – human, technical and financial, are available, in both Municipality and PUC, for establishing and maintaining the asset management system.

The responsibilities of Asset Managers should include, but not be limited to, the following:

- The overall design, documentation, review and improvement of asset management system;
- Ensure that asset management documentation/protocols/processes are clearly communicated to all relevant staff;
- Ensure that all relevant staff have a full understanding of their own individual roles and accountability within the asset management system;
- Ensure that staff receives sufficient training in implementing AM practices;
- Monitor implementation of AM techniques by responsible staff;
- Manage and monitor staff performance;
- Monitor and report changes in the condition, performance and risk profiles of individual assets;
- Prepare and review timely asset management reports.

The responsibility for the AM activities has to be driven from the top down, which is why it is necessary to firstly have the senior level responsibility (Asset Managers). Secondly, all other roles that are important for implementation of AM system have to be defined and documented as well, such as: engineers, designers, technical specialists, process operators, maintenance personnel, economists, legal personnel, etc. Specific role/job descriptions should be developed, containing clear measurable expectations for each individual role.

It needs to be kept in mind that the decision-makers do not need to form a separate organization department for asset management, but rather, asset management has to be entrenched into the existing organization and the existing working staff. Senior level responsible staff has to facilitate the change that needs to take place within the organization and staff’s everyday activities. Asset management must not be perceived as a project but has to be adopted as an improved way of doing business.

2.5.3.2 Communication, knowledge and training

Commitment to implementing asset management system must be communicated to all relevant staff. In order to fulfil their part within the AM system staff has to be clearly assigned with their own individual responsibilities, they should know what is expected from them and what knowledge and competencies they are required to have.

Organizational structure, working protocols and procedures, importance of meeting asset management requirements, should all be communicated to the relevant staff.

A gap analysis between the skills and competencies of staff required by AM system and the currently available ones (within the Municipality and PUC) will show what kind of capacity building / training of staff is necessary in order to meet the requirements of AM in the future. The training service is normally contracted from outer sources.

2.5.4 Asset management techniques

2.5.4.1 Asset data collection

In order to start with any planning of future actions, it is necessary to have a certain degree of information about the assets owned and where the assets are located.

Asset data may be collected in one of the following ways:

- On-site surveys, field inspections,
- Photographs, videos,

- Data from projects and studies (as-built drawings, design drawings),
- Data from suppliers'/manufacturers' manuals,
- Data collected during regular maintenance,
- Data collected from the staff.

As assets, which make up a WS and WW system, are numerous, they need to be divided into groups/categories of assets, according to the type and characteristics of assets, by using hierarchical approach – parent-child approach (Figure 2). The depth of asset hierarchy can be chosen by decision-makers based on the resources available for data collection.

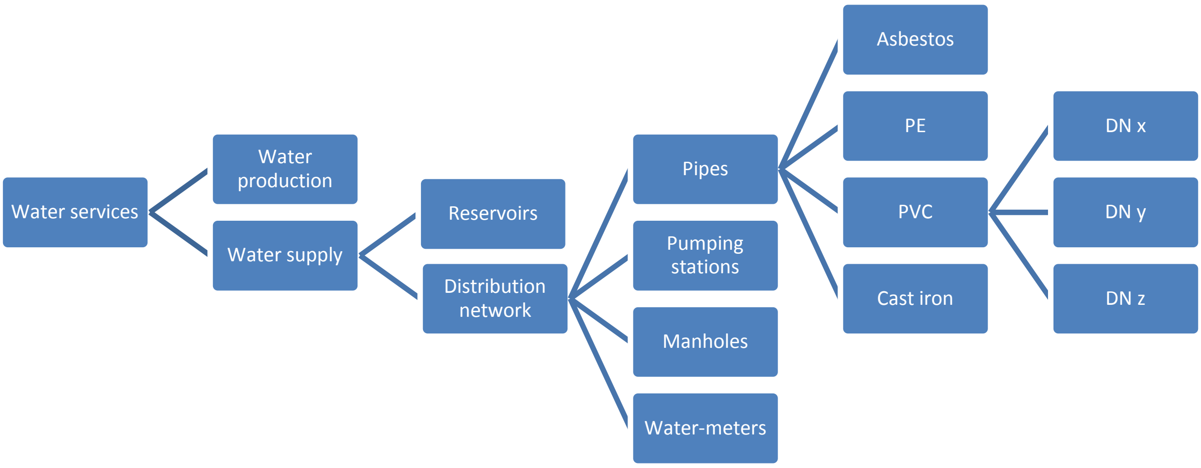

Figure 2: Example of asset hierarchy

Asset data collection can be divided into steps/levels following a "tree" structure, starting with the top level of the "tree" and gradually fulfilling the levels below. It is important to note that the lack of detailed data inventory is not a barrier to the development of an initial asset management system. Although the inventory will be needed at some point, it is entirely appropriate to build the initial system with limited data.

Each identified asset can have numerous data/attributes assigned to it. The following asset data is recommended to be collected:

- Age, condition, location;
- Size and capacity;
- Manufacturer and construction materials;
- Installation data and expected service life;
- Maintenance and performance history;
- Failure history;
- Criticality, derived from the utility's risk management framework.

As some of the collection methods are more reliable than others, reliability of gathered data can also be rated, based on the rating criteria: high, medium, low.

It is required to develop a written protocol of asset data collection and asset hierarchy. It is also required to develop Asset Data Collection Forms. Different forms should be developed for different asset categories, as each asset category has specific characteristics that need to be described. Table 1 presents an example of asset collection form.

Asset data collection form			
Civil structure assets - reservoirs			
Location name and address:			
Size/capacity:			
Condition grade (1-5):			
Construction Materials:		Date of Installation:	
Comments (on condition and necessary maintenance and repair):			
Reliability of data:			
Associated Equipment:			
Flow meters	Flow Meter (1)	Flow Meter (1)	Flow Meter (1)
Manufacturer			
Size			
Serial number			
Condition			
Comment:			
Other comments:			

Table 1: Example of asset data collection form

2.5.4.2 Condition and performance assessment

It is critical that decision-makers have a clear knowledge of the condition of their assets and how they are preforming. The objective of these two aspects of assets is to enable assessment of future demands for minor and major repairs, rehabilitation and replacement.

There are many ways to assess the condition of assets. The condition of some assets can be visually assessed, but for some others analogue or digital testing may be required. For example, water lines can be pressure tested or leak tested, pumps can be monitored for energy efficiency, etc. The condition of some assets can be assessed using knowledge and experience of the staff.

The condition of an asset implies not only its age but also its ability to provide the required level of service, at a reasonable level of maintenance. Therefore, when rating an asset condition, a necessary level of maintenance/investment can also be identified.

Basic condition grading approach is presented in Table 2. However, a more detailed condition grading can be developed, for example, for major asset categories, such as: buildings, reservoirs, pipes, electrical & mechanical equipment, etc.

For companies just starting to implement AM, a simple scoring system should be applied, e.g. grades from 1-5.

Condition Rating	Description	Maintenance Level
1 excellent	Asset is like new, fully operable, well maintained, and performs consistently at or above current standards. Little wear shown and no further action required.	Normal preventive maintenance
2 good	Asset is sound and well maintained but may be showing some signs of wear. Delivering full efficiency with little or no performance deterioration. Virtually all maintenance is planned preventive in nature. At worst, only minor repair might be needed in the near term.	Normal preventive maintenance, minor repair
3 moderate	Asset is functionally sound, showing normal signs of wear relative to use and age. May have minor failures or diminished efficiency and some performance deterioration. Likely showing modest increased maintenance and/or operations costs. Minor to moderate refurbishment may be needed in the near term.	Normal preventive maintenance, major rapair
4 poor	Asset functions but requires a sustained high level of maintenance to remain operational. Shows substantial wear and is likely to cause significant performance deterioration in the near term. Near term scheduled rehabilitation or replacement needed.	Major repair, rehabilitate
5 failing	Effective life exceeded and/ or excessive maintenance cost incurred. A high risk of breakdown or imminent failure with serious impact on performance. No additional life expectancy; immediate replacement or rehabilitation needed.	Replace

Table 2: Example of asset condition grading

Normal preventive maintenance includes regularly scheduled maintenance activities such as inspection programs, cleaning, lubricating, etc.

Minor repair includes minor repairs for water and wastewater systems, replacement of asset smaller parts, etc.

Major repair includes activities such as repairing broken mains, replacing motors or pumps, and similar unscheduled or unplanned emergency activities carried out to maintain service for water and wastewater systems.

Rehabilitation is generally a one-time event designed to extend the life of the asset, such as installing cathodic protection in a water system.

Replacement is the unavoidable event that occurs at the end of the service life of all assets. For water and wastewater systems, replacement usually means open-cut installations.

If decision-makers wish, and have the resources available, they can employ a more complex grading which includes a more detailed performance assessment of asset. This is a matrix scoring system with multiple performance indicators and weightings to derive a score:

- Physical condition – The current structural state of the asset resulting from an interaction of usage, age, maintenance, design.
- Operational performance – The current ability of the asset to meet operational requirements now and in the foreseeable future. This indicator is influenced by required levels of service/asset performance, technical obsolescence, operations and maintenance policies and history, and design effectiveness/process efficiency.

- Reliability – the ability of an asset to perform its required function under stated conditions for a specified period of time; reliability is often considered as —how frequently an asset fails.
- Availability – the percentage of time that an asset is capable of functioning relative to the time that the user expects it to function; availability is largely a function of the frequency of breakdowns and their duration.
- Maintainability – those characteristics of design and installation which determine the probability that a failed asset can be restored to its normal operable state within a given timeframe using prescribed practices and procedures. Its two main components are serviceability (ease of conducting scheduled inspections and servicing) and reparability (ease of restoring service after a failure). This is often measured in terms of - mean time to repair.

Indicator	Score and description				
	1	2	3	4	5
Physical condition	Exceeds current requirements	Meets current requirements but with room for improvement	Obvious concerns: cost/benefit questions	Inefficient; becoming ineffective, obsolete	Failing, not capable of sustaining required performance
Operational performance	Exceeds current requirements	Meets current requirements but with room for improvement	Obvious concerns: cost/benefit questions	Difficult to sustain performance	Failing, not capable of sustaining required performance
Reliability	As specified by manufacturer	Infrequent breakdown	Occasional breakdown	Periodic breakdown	Continuous recurrent breakdown
Availability	Virtually always operational	Out of service only for very short periods	Out of service for moderate period; moderately difficult to return to service	Extensive downtime duration; difficult to return to service; parts, difficult to acquire, rare skills required	Virtually impossible to return to service; parts no longer available; unavailable trained personnel
Maintainability	Preventive maintenance only; baseline monitoring	Minor corrective maintenance required; shortening of monitoring intervals	Predictive and corrective maintenance becoming dominant; frequency of work orders increasing substantially	Work orders well above average for type of asset; recurrent minor repair; close monitoring required	Corrective maintenance is frequent with recurrent patterns of failure; asset must be virtually constantly monitored or "run to failure" response readied for implementation

Table 3: Example of asset performance grading

It is required to develop a written protocol of asset condition and performance assessment methodology.

2.5.4.3 Criticality/Risk assessment

After determining the asset condition and the required level of maintenance/investment, the next step is to identify the risk of asset failure. The reason is to help prioritize the most critical assets, as the limited budgets of PUC and Municipality cannot afford to implement all the necessary maintenance and capital investment actions/interventions at once. Therefore, the purpose for identifying critical assets is to allow the decision-makers to make more informed decisions regarding the use of their budgets. The most critical assets are those assets that are likely to fail and have a significant consequence if they fail. Furthermore, failures of the most critical assets tend to have the highest costs.

When determining the asset criticality, decision-makers need to look at what they know about the likelihood that a given asset is going to fail. The following components are considered when determining the likelihood of asset failure:

- Asset Age: The asset's age can be a factor in determining likelihood of failure, but should not be a sole factor. Over time, assets deteriorate, either from use or from physical conditions such as interaction with water or soil, and are more likely to fail. An asset's useful life is highly related to the conditions of use, the amount of maintenance, the original construction techniques, and the type of material it is constructed out of.
- Asset Condition: One of the most important factors in determining an asset's likelihood of failure is the condition of the asset. As the asset's condition deteriorates, it will become much more likely to fail. It is important, therefore, to make the best attempt possible to give the assets a reasonable condition assessment. The condition assessment should also be updated over time, so that criticality can likewise be updated.
- Failure History: It is important to monitor when assets fail and record the type of failure that occurred. This information should be as specific as possible to assist the system in understanding its failure modes. Past failure is not a complete predictor of future failure, but it can provide some indication of the likelihood of future failure, especially if detailed information on the failures is collected and reviewed. Asset management system should track and analyse failure history on all of the asset categories, including the following information of failures:
    - Type of failure (rupture, mechanical failure, small leak),
    - Failure cause, reasons why failure occurred - root cause and contributing causes;
    - Failure mode, mechanism of failure - systematic series of sequential and interrelated causal steps that lead to the failure of an asset;
    - Failure behaviour – evident, hidden, random
- General Experiences with the Asset: Although likelihood of failure is site specific, some guidance regarding likelihood of failure can be gained by examining experience with that type of asset in general. For example, if there is a history of a certain type of pump failing frequently after 2 years of use, and a system has that type of pump and it is currently 18 months of age, the asset may be given a higher likelihood of failure than it would be if there was no general experience of this type.

The factors discussed above can be taken together to predict how likely an asset is to fail. The rating scale should be kept simple, e.g. rating from 1 to 5.

In terms of the consequence of failure, it is important to consider all of the possible costs of failure. The following components are considered when determining the consequence of asset failure:

- Cost of Repair: When an asset fails, it will be necessary to fix the asset in some way. Depending on the type of the asset and the extent of the failure, repair may be simple or extensive. If the asset can be repaired easily and without a tremendous cost, then there is a lower consequence. If the cost of repair is higher, then the consequence of the failure is also greater.
- Social Costs Related to the Loss of the Asset: When an asset fails, there may be an inconvenience to the customer. In some cases, this inconvenience may be minor, while in other cases, the social costs may be much higher. For example, if a pipe must be repaired in a residential area, there may be a few customers who are out of water for a short period of time. In this situation, the cost of the consequence of failure related to the social cost is low. On the other hand, if the system has very few isolation valves so that any repair on the system requires the whole system to be shut down, the inconvenience to the customers is much greater. In this situation, the cost of the consequence of failure related to the social cost is high.
- Repair/Replacement Costs Related to Collateral Damage Caused by the Failure: When an asset fails, in some cases damage may be caused to other assets unrelated to the water or wastewater system. Examples of this type of damage include the following: a water line fails causing a sinkhole which then causes damage to the foundation of a building or a house or causes major sections of a road to collapse. Therefore, there is collateral damage. The utility will be held responsible for this collateral damage, so the costs related to this type of failure need to be considered in the assessment of costs of the consequence of failure.
- Environmental Costs Related to the Failure: Some types of asset failures can cause environmental impacts. The costs related to these impacts may not always be easy to assess in monetary terms. However, some attempt should be made to establish some type of monetary value to the environmental consequences. An ex ample of an environmental cost related to a failure would be a sewer pipe that leaked sewage into a waterway or onto land. A value, either monetarily or qualitatively, would need to be placed on this type of consequence.
- Reduction in Level of Service: The assets must be in working order to deliver the level of service desired by the water system and its customers. If the assets fail, the ability to deliver the desired level of service may be compromised. An asset that has a major impact on the ability to meet the LOS would be considered more critical to the system than an asset whose failure would not have a significant impact on the LOS.

The factors discussed above can be taken together in assessing the consequence of failure. The rating scale should be kept simple, e.g. rating from 1 to 5.

The next step is to multiply the ranking of likelihood with the ranking of consequence of failure, obtaining the final score of asset’s criticality. The criticality matrix is presented below.

Multiplied		Consequence (Cost) of Failure				
		1	2	3	4	5
Probability of Failure	1	1	2	3	4	5
	2	2	4	6	8	10
	3	3	6	9	12	15
	4	4	8	12	16	20
	5	5	10	15	20	25

Table 4: Asset criticality matrix

A risk matrix should have at least three risk levels (low, medium and high risks) that are to be associated with the acceptance levels of risk: low or acceptable risk (1-6); medium or tolerable risk (8-12); and high or unacceptable risk (15-25).

It is necessary to periodically review the criticality analysis and make adjustments to account for changes in the likelihood of failure and the consequence of failure.

It is required to develop a written protocol of criticality/risk assessment methodology.

2.5.4.4 Life-cycle asset management

The economic principle states that one's needs will always exceed the ability of one's resources to satisfy those needs. Budget constraints are a reality of life. In the face of funding constraints it is important to prioritize spending. Spending on current assets should be targeted at meeting the needs of the most critical assets first. Spending on new assets should be prioritized in such a way that the organization achieves the most benefit for the cost that it will incur.

The infrastructure life-cycle approach comprises following phases:

- Planning of the full asset life cycle;
- Establishment/creation of the infrastructure asset (design, procure and construct);
- Operation and maintenance of the infrastructure asset;
- Rehabilitation/renewal of the infrastructure asset.

Decision-makers must include all phases in planning process. Many project plans do not consider the challenges and costs after construction, which can have a significant impact on the technical solution and the long-term viability of the infrastructure.

It is often tempting to try and save costs through cheap construction methods or cutting back on operations and maintenance costs. However, construction cost is only a component of lifecycle cost, and construction savings now can lead to higher lifecycle costs later on. O&M savings, on the other hand, lead to shortening assets useful life and earlier need for rehabilitation and/or replacement. Therefore, decreasing costs in short-term leads to increasing costs in long-term.

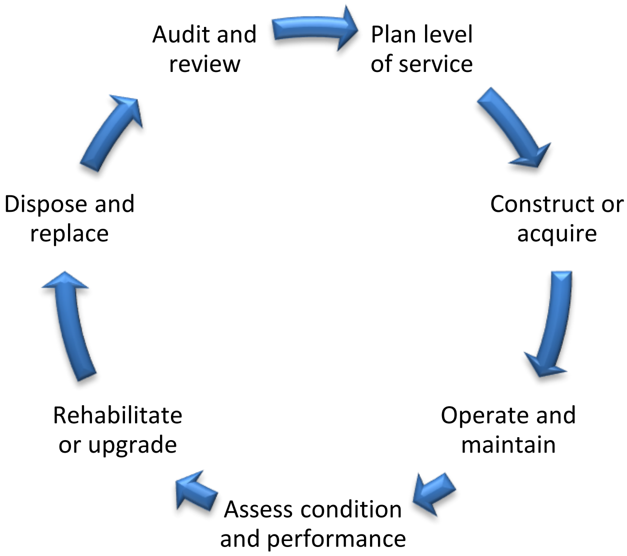

Figure 3: Life-cycle asset management

Life-cycle asset management aims to achieve the following three objectives:

- Ensure that the asset at a minimum achieves its original design or estimated useful life. This is done through *proper operations and maintenance*. When a poor maintenance regime is followed, the asset may not reach its design life, and financial losses will be incurred.

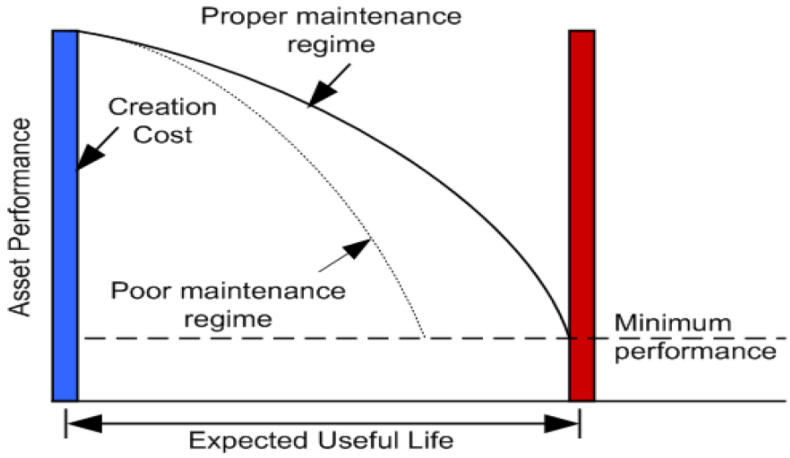

Figure 4: Link between proper maintenance and expected useful asset life

- Extend the life and/or capacity of the asset through *selective renewal/rehabilitation* at strategic points, rather than to fully reconstruct the asset at greater cost.

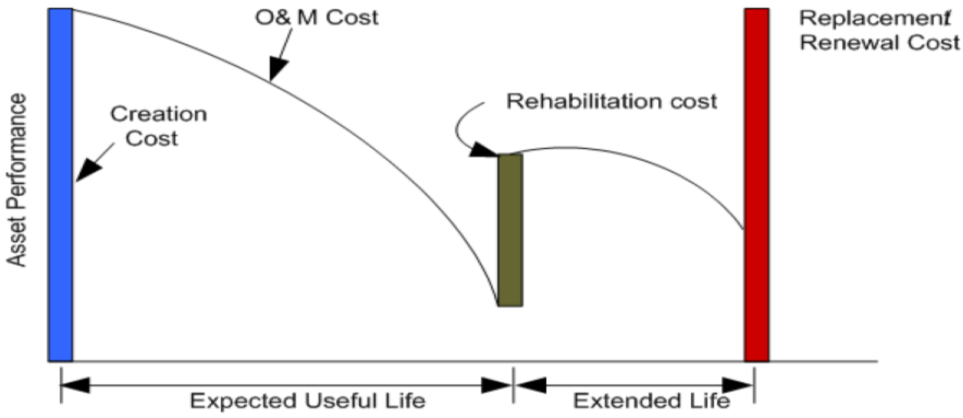

Figure 5: Link between strategic rehabilitation and extended asset life

- Minimize the overall lifecycle costs through correct design and trade-offs between different lifecycle cost components and proper timing of lifecycle actions.

2.5.4.5 Asset valuation

International Accounting Standard 16 for "property, plant and equipment" permits two accounting models for fixed assets: cost model and revaluation model. The benefits of revaluation of assets is reflected in making the accounting data more related to economic realities and the fair value in order for different decision-makers to make more informed decisions based on these data.

Public Utilities usually keep the value of their assets in the Book of Fixed Assets containing data such as: purchase value, depreciated value, and current value of assets. However, the book value of water and sanitation assets does not present their real value, as the real or fair value of assets requires a periodic revaluation. Fair value of utility assets could be defined as the value of the remaining useful life of assets.

Fair value can be based on market value where this can reasonably be established, such as for land and office buildings, but infrastructure will usually be assessed using a depreciated replacement cost approach. This approach recognises that a range of factors, including the quality of maintenance, may affect the life expectancy of an asset. Consequently periodic re-assessment of actual remaining useful life is essential, particularly as the lives of infrastructure assets may span several decades.

Depreciated Replacement Cost (DRC) can be calculated as follows:

$$\text{DCR} = \frac{RUL}{EUL} x\ CRC$$

where:

RUL = Remaining Useful Life, established as follows: (a) above ground assets – by visual assessment of condition and knowledge of the maintenance regime (see Table 2); (b) below ground assets – EUL minus age (since construction or last renewal);

EUL = Expected Useful Life, which is the anticipated life of an asset from acquisition or renewal until failure, taking into consideration the operating environment and the maintenance regime;

CRC = Current Replacement Cost, which is an estimate of the current cost of replacing the asset with a modern equivalent of similar capacity, based on unit rates. The unit rates should include the cost of the asset, materials and labour associated with construction, as well as planning, design and supervision costs where applicable, and VAT.

Asset valuation is crucial for decision-makers to be aware of the real/remaining value of their assets, and to understand the cost of future asset maintenance requirements and to make sure there is sufficient funding to maintain the network in the long term.

2.5.4.6 Options for interventions

The previously undertaken asset management techniques should have already indicated to the decision-makers: a) which asset need normal/regular maintenance and those that require certain capital investments, and b) the priority of undertaking specific measures.

In addition, undertaking further options analysis might be necessary to define the best available option. This analysis compares different actions that would enable assets to provide the needed levels of service.

Options may be further compared based on:

- Lifecycle cost – the total cost of constructing, maintaining, renewing and operating an infrastructure asset throughout its service life. Future costs must be discounted and inflation must be incorporated. Decision-makers need to use appropriate indices to calculate discount or inflation rates.
- An assessment of all other relevant direct and indirect costs and benefits associated with each option. Examples include:
    - Efficiencies and network effects (such as savings in energy consumption when replacing old pumps).
    - Safety and environmental impacts;
    - Etc.

The following paragraphs provide information on the requirements of the identified options for dealing with assets.

Operation and maintenance

Operation and maintenance (O&M) functions relate to the day-to-day running and upkeep of assets. Regular O&M is defined as normal support, periodic and minor in nature, required to sustain performance and functionality of an asset consistent with design, manufacturer, and operational requirements.

Properly operating and maintaining assets is critical to the effectiveness of the whole company. Effective operation and maintenance practices are critical to achieving the objective to provide the required LOS at the lowest possible life-cycle cost. The primary goal of maintenance is to avoid or mitigate the consequences of failure of assets, which can be costly.

Roughly, preventive maintenance costs one-third less than reactive maintenance for the same task. Reactive emergency maintenance can be the most expensive type of maintenance and should typically make up no more than 20% to 25% of total maintenance effort.

Preventive maintenance can be described as maintenance of equipment or systems before failure occurs. It can be divided into two subgroups:

- Planned maintenance, a scheduled inspection to ensure that an asset is operating correctly,
- Condition-based maintenance, performed after one or more indicators show that asset is going to fail or that equipment performance is deteriorating.

It is recommended to establish standardized procedures for operation and maintenance.

Operational procedures can be classified as:

- Standard Operating Procedure: used on a daily basis during normal operation conditions;
- Alternate Operating Procedure: used periodically when asset taken off service due to scheduled repair;
- Emergency Operating Procedure: used in emergency conditions during asset failure.

Maintenance procedures can be classified as:

- Preventive Maintenance Procedures: developed to prevent breakdown and prolong asset life;
- Reactive Maintenance Procedures: used for repair of assets that are malfunctioning.

Example of maintenance schedule is given in table below.

Asset category	Likelihood of failure	Consequence of failure	O&M activities	Condition assessment activities
0-30 year old PVC distribution pipes and associated parts in residential area	Low	Low	Flush pipes 1/year Exercise valves 1/year 500 EUR/year	Track break locations and break information (type, repair, size, etc.) based on field activity and work orders 500 EUR/year

Table 5: Maintenance schedule example

It is very important to have a work order for every maintenance activity, containing the following information:

- information whether it is planned or unplanned maintenance;
- estimated costs of maintenance;
- used labour;
- used materials;
- failure cause;
- failure mode (manner in which the asset failed);
- the impact on customers (service);
- unproductive time of asset;
- other issues.

Data from the work orders can be very helpful for many types of analysis useful in asset management: life-cycle cost analysis, failure cause and failure mode analysis, failure consequence analysis, asset efficiency analysis, etc.

Repair, rehabilitation and replacement of assets

When a failure occurs, the asset can be repaired, rehabilitated, or replaced.

Asset repair is restoration beyond normal periodic maintenance, relatively minor in nature with no enhancement of asset capabilities. Asset rehabilitation means replacement of a component to return the asset to the level of performance above the minimum acceptable level, may include minor enhancement of asset capabilities. Asset replacement is substitution of an entire asset with a new asset.

The choice of the type of intervention is determined based on the condition and performance of assets, whereas the priority and timing of intervention is determined based on criticality assessment.

Interventions may be divided into two categories: a) routine repair and replacement, and b) major rehabilitation and replacement.

Routine repair and replacement can be scheduled quite easily, based on past experience, in periodic intervals. Example of repair and replacement schedule is given in table below.

Year	Item	Intervention	Costs estimation (EUR)	Time period of reoccurrence
2015	Meters	Replace 1/5 of meters	10.000	Every 5 years

Table 6: Repair and replacement schedule example

It is recommended that major rehabilitation and replacement are planned within a more detailed capital improvement plan which should look at the utility's needs for the future with a minimum of 5 years planning period.

The categories of capital improvement plan could be the following:

- capital needs related to major asset rehabilitation and replacement;
- capital need related to WS and WW system expansion;
- capital needs related to improved technology (e.g. SCADA system).

Year	Project name	Project description	Project need	Date flexible	Cost estimation	Funding source	Changes in operation	Impact on LOS
2015	Replace reservoir	Replace with new larger	Reservoir reaching the end of useful life, size needs to be increased	yes	100.000	50% own resources 50% loan	May require changes in the amount of time wells are pumped	Improve system's overall quantity of storage, improve system pressure and water availability

Table 7: Capital improvement plan example

2.6 IMPLEMENTATION OF ASSET MANAGEMENT PLAN

2.6.1 Approach

In preparing AM plan it is important to have an overview on the existing situation regarding requirements set in AM strategy by defining which of those can be achieved and in which extent in the medium term (e.g. five-to-ten year plan). AM plan is a strategic document that states how a group of assets are to be managed over a period of time. In particular, it identifies perceived strengths and weaknesses, and crucially, things that could be done better.

Development of AM plan implies, at least, the following:

- development of specific targets and metrics for the required level of service,
- detailed engineering screening of the current WS and WW system (assets) using asset management techniques, as well as hydraulic modelling,
- proposal of activities for improvement of current WS and WW system (assets) for meeting the required level of service,
- detailed analysis of non-asset aspects of AM (human resources, IT technology) and proposal of activities for improvement.

AM plan also presents a summary of all findings during the previous phases of asset management system and provides a tool to decision-makers for justification of maintenance and capital investment interventions.

Benefits of AM Plan are that it:

- Provides a central inventory of assets;
- Provides consistent information;
- Links investment with service levels through performance and condition grades;
- Values assets;
- Plans and prioritises investment;
- Measures improvement over time.

2.6.2 AM Plan requirements

The starting point in developing an Asset Management Plan is to have some level of inventory of assets. After compiling an inventory, development of AM plan continues with defining a more detailed required level of service for the planning period, as all other activities are targeted to achieve that level of service. The AM Strategy has already given some indication of the level of service, but in general terms, based mostly on regulatory and customers' requirements. AM Plan should provide the level of service in more detail, indicating how the system should behave, as well as what activities should the utility provide, in order to meet the regulatory and customers' requirements.

2.6.3 Methodology

Considering that AM plan presents a document that should also compile results of asset management techniques, methodology of development of AM plan includes those methodologies as well.

Methodology for the development of AM plan includes few main segments:

- Compilation of asset data based on:

    - Collection and analysis of existing studies and documents;
    - Meetings with staff;
    - Filed inspections.
- Definition of expected level of service is based on:
    - Analysis of legal requirements;
    - Survey of customers' expectations.
- Development of programme of measures is based on:
    - Preparation of hydraulic models and calculations;
    - Assessment of existing infrastructure operations;
    - Definition of programme/project elements;
    - Conceptual engineering of programme/project elements (and variants);
    - Cost estimates for investments, operation and maintenance;
    - Evaluation of variants (multi criteria matrix with monetary and non-monetary criteria);
    - Proposal for an improved operation concept – activities that optimize costs, risks and performance of assets.
- Financing strategy is based on:
    - Financial analysis of costs and revenues of PUC, including cost coverage, tariff analysis, collection efficiency;
    - Financial analysis of municipal budgets;
    - Assessment of willingness and affordability of customers to pay for the services.

2.6.4 Document format

The plan describes the characteristics and condition of infrastructure assets, the levels of service expected from them, planned actions/interventions to ensure the assets are providing the expected level of service, and financing strategies to implement the planned actions. A detailed asset management plan has the following sections:

- Executive summary
- Introduction
- State of the assets
- Expected levels of service
- Programme of measures
- Financing strategy

2.6.4.1 Executive summary

The executive summary is typically the final section to be prepared, and provides a concise overview of the plan.

2.6.4.2 Introduction

The introduction:

- explains how the municipal strategic goals, related to water supply and wastewater, are dependent on infrastructure assets. This could include discussing how infrastructure assets support economic activity and improve quality of life. The municipality's goals may already be set out in the AM strategy;

- describes to the public the purpose of the asset management plan (i.e. to set out how the infrastructure assets will be managed to ensure that they are capable of providing the expected levels of service);
- states which infrastructure assets are included in the plan;
- identifies how many years the asset management plan covers and when it will be updated. Plan may cover 5-10 years and be updated regularly;
- describes how the asset management plan was developed — who was involved, what resources were used, any limitations, etc.;
- identifies how the plan will be evaluated and improved through clearly defined actions.

2.6.4.3 State of the assets

This section summarizes in one or more tables:

- Asset types, size and quantity;
- Financial accounting valuation and replacement cost valuation. Financial valuation uses historical costs and depreciation assumptions. Replacement cost valuation is forward-looking and accounts for expected inflation, changes in technology and other factors;
- Asset age distribution and asset age as a proportion of expected useful life;
- Asset condition, performance and risk profile.

This section also discusses how and when information regarding the characteristics, value, and condition of assets will be updated.

This section is supported by:

- an inventory database of infrastructure assets covered by the plan;
- asset data collection and hierarchy protocol;
- condition assessment and risk assessment protocol.

2.6.4.4 Expected levels of service

This section:

- defines levels of service through performance measures, targets and timeframes to achieve the targets if they are not already being achieved. For example, levels of service for a water system could include:
    - “X” breaks per 100 km of watermains per year are acceptable;
    - watermain breaks will be repaired within “X” hours of initiation of repair, 95% of the time;
    - customer complaints will be responded to within 24 hours;
    - meeting of all regulatory requirements.
- discusses any external trends or issues that may affect expected levels of service or the public utility’s and municipality’s ability to meet them (e.g., new accessibility standards, climate change impacts).
- shows current performance relative to the targets set out. A table may be useful for this.

This section is supported by documentation that specifies which performance measures are associated with which assets, current performance and expected performance over the planning period, as well as all assumptions. One way to link performance measures and current/expected performance to the relevant assets is through the asset inventory database.

2.6.4.5 Programme of interventions

The programme of interventions is the set of planned measures/projects that will enable the assets to provide the desired levels of service in a sustainable way, while managing risk, at the lowest lifecycle cost.

This section of the asset management plan:

- summarizes planned interventions, including:
    - Non-infrastructure / institutional measures – actions or policies that can lower costs or extend asset life (e.g. better integrated infrastructure planning, demand management, process optimization, managed failures, etc.).
    - Maintenance activities – including regularly scheduled inspection and maintenance, or activities associated with unexpected events.
    - Renewal/rehabilitation activities – significant repairs designed to extend the life of the asset.
    - Replacement activities – activities that are expected to occur once an asset has reached the end of its useful life and renewal/rehabilitation is no longer an option.
    - Expansion activities – planned activities required to extend services to previously unserviced areas - or expand services to meet growth demands.
    - Improved technology activities – assets may be replaced because the technology of assets originally installed is out of date and needs to be modernized or because technology improvements will allow improved customer service or enhanced efficiencies.
- Includes an overview of the risks associated with the programme (i.e. ways the plan could fail to generate the expected service levels) and any actions that will be taken in response.

Considering that assets that constitute WS and WW system are interdependent, the whole system should be viewed when choosing interventions. In that sense, the asset management programme of measures should be viewed as the set of actions that, taken together, has the lowest total cost — not the set of actions that each has the lowest cost individually.

2.6.4.6 Financing strategy

A financial plan is critical for putting an asset management plan into action. In addition, by having a strong financial plan, decision-makers can demonstrate that they have made a joint effort to integrate asset management planning with financial planning and budgeting and to make full use of all available financing tools.

This section:

- shows yearly expenditure forecasts broken down by:
    - Non-infrastructure / institutional measures;
    - Maintenance activities;
    - Renewal/rehabilitation activities;
    - Replacement activities;

    - Expansion activities;
    - Improved technology activities.
- provides actual expenditures for these categories from the previous two to three years for comparison purposes;
- gives a breakdown of yearly revenues by confirmed source (PUCs own sources and available municipal budget);
- discusses key assumptions and alternative scenarios where appropriate;
- identifies any funding shortfall relative to financial requirements that cannot be eliminated by revising service levels, asset management and/or financing strategies, and discuss the impact of the shortfall and how the impact will be managed.

This section is supported by documentation explaining how the expenditure and revenue forecasts were developed. Expenditure forecasts must be consistent with the options analysis (described in chapter 2.4.4.5.). Revenue forecasts must be documented separately, along with the assumptions made and alternative scenarios.

2.7 MONITORING PERFORMANCE AND IMPROVEMENT

Asset managers should periodically (e.g. annually) monitor performance of asset management practices in meeting strategic goals and objectives. The purpose of monitoring is to determine whether the asset management system has been implemented and maintained, and is effective in meeting the municipal and PUCs overall objectives regarding provision of WS and WW services.

Elements of monitoring have to be established by decision-makers in the form of written protocol or procedure, and regularly implemented by senior staff of both decision-makers.

Monitoring protocol or procedure should address the following:

- The responsibilities and competences for planning and conducting monitoring and reporting results;
- Determination of monitoring criteria, scope and methods.

Monitoring can be carried out by staff within the organisations or by external experts.

Based on monitoring results, appropriate improvement actions shall be defined and implemented.

2.8 ASSET MANAGEMENT AND GENDER ISSUE

Gender issue in the framework of asset management can be viewed as two-sided. One side is equal participation of men and women in decision making in water and sanitation sector. In this regard, specific gender objectives need to be articulated within national water and sanitation policies and strategies. The other side is influence of availability of water and sanitation services on gender issues. Namely, water availability and quality disproportionately affect women due to their gendered responsibilities for family's basic needs and health. Asset management as a tool for improving utility services may be considered as having a positive impact on provision of equal rights for men and women. Furthermore, in cases of consulting stakeholders'/customers' opinion to influence PUs' plans, budgets and strategies, care should be taken to include the voices of both women and men equally.

3 ASSET INFORMATION MANAGEMENT

3.1 INTRODUCTION

Management, in the broadest meaning of the term, is not feasible without owning and managing information. Accordingly, the infrastructure asset management is based on one of the key preconditions, owning the data, information and knowledge concerning the property.

The ISO 55000 series of international standards focuses on asset management and requires organization applying it to identify information and their required quality to effectively manage assets on strategic and operational levels. The standard also requires the development and maintenance of information management in order to ensure that the information is consistent, maintained, controlled and available to those who need it.

In practice, the distinction between information management system and information systems is commonly misperceived. Organizations that have a need for asset management, ordinarily invest significant resources in implementation of information systems that support asset management-related business processes. However, the benefits in terms of results are difficult to quantify, so the decision-makers are still faced with significant problems in obtaining the information necessary for management of assets.

Effective asset information management is a key aspect of asset management, regardless of whether it is based on sophisticated information system based on relational databases or information systems based on historical documents in paper form, supported by simple electronic registers. An information management system relies on understanding and managing information, understanding value of information, understanding information needs and context of information and dedication to continually maintaining information quality.

The subsequent chapters are therefore dedicated to these aspects of asset information management systems, aiming to establish meaningful groundwork for implementation or acquisition of information systems with the intention to facilitate asset management process in its entirety. Intended beneficiaries of this toolkit are all those involved in, or responsible for the use or management of asset information, decision-makers, engineers and IT specialists, but does not exclude the general audience that is interested in better understanding the significance of good practices in managing asset information.

We emphasize that this toolkit does not aspire to provide the practical aspects of implementation in terms of the use of particular information technology and information systems, although they will be referred to at some points within it, to support better understanding of the matter. The purpose of this toolkit is to raise awareness of the understanding that the most important improvement in terms of information needs for asset management refers to the processes of their collection, organization and use, and that it does not necessarily depends on the chosen technology or information systems.

3.1.1 Asset Information

Asset information is a combination of data on physical assets that is used to inform decision-makers about how the assets were managed.

Asset information is a common term that incorporates the following types of general information:

- Records of the existence of physical assets, most commonly known under the term asset register;
- Attributes related to the assets, such as: manufacturer, model, serial number, year of putting into use, capacity, etc.;
- Location - the spatial information about the assets location and information of relation to other assets, usually in a geographical information system (GIS);
- Subjective information about assets such as asset performance, condition, expected lifecycle, estimated maintenance possibilities, etc.;
- Planned short-, medium- and long-term activities on maintenance and history of previous maintenance operations;
- Documents, drawings (CAD) and photographs of assets.

It is impossible to make good decisions concerning asset management without good information, such as determining the optimal maintenance frequency or asset renewal. Such decisions must be based on information about the location and status of assets, failure probability and its impacts, as well as information about the cost of maintenance, resources that are available and other business priorities. That means that asset information are very valuable and very important role in the efficiency and performance of organizations whose business activities are based on effective asset management. A high value carries with it a high cost of asset information management. The cost of asset information management includes not only the costs of collection, recording and storage of information, but also hidden costs, such as: information retrieval time, collection and processing of information from different sources and formats and very frequent recurrence of these activities for the needs of different groups of users and business processes. Using various technologies and information systems carries as little as 2 to 5 per cent of the total cost of asset information management. However, a much larger part of the total cost is originates from the asset information management system - 20 to 30 per cent, while the remaining portion of the cost relates to the very process of asset management.

3.1.2 Asset Information Management Strategy

Understanding what information is needed, how it should be collected, stored, organized and analysed is a complex issue for all organizations where the asset management process is one of the most important processes within their core business. While technology and various information systems for storing and managing asset data play an important role, asset information management systems are confronted with much broader challenges, such as:

- What asset information we truly need and why?
- How to facilitate measuring and ensure quality of information?
- What are the risks we are willing to accept if the information quality is not good?
- How should collection, storing, maintenance and management of asset information be controlled?

- How to ensure that all users of information understand the significance of information and its role in the whole life-cycle of assets?
- How information and other technologies fit in to all these aspects?
- How to increase benefits from existing systems and processes?

Answers to these questions cannot be provided without a systematic approach to managing asset information. The systematic approach involves defining an **asset information management strategy**. The strategy needs to define how an organization intends to assure collection, organization, maintenance, use and analysis of asset information in order to effectively support processes of both strategic and operational execution of activities throughout the entire asset life-cycle. It needs to be consistent with the overall management strategy of the organization and its objectives, in the manner also required by the ISO 55000:2014 asset management standard.

Asset information management strategy needs to include:

- Key decisions and information necessary for their adoption;
- Interrelationships with business processes relevant to asset management;
- Proposed approach to defining information requests, which should include the cost of providing asset information;
- Flow of information, system interfaces and logical data models;
- Organization of information and data management;
- Costs, benefits, and timing of activities to accomplish necessary improvements in asset information management;
- Key asset information system functionalities that need to be supported or that are mandated;
- Requirements for the essential, most important asset information systems;
- Elaboration of various information systems integration (both the existing and projected);
- Strategy for migration of existing information systems to newly introduced information systems.

Asset management standard requires that information management strategy includes objectives pertinent to proposed improvements to the asset information management that need to be specific, measurable, achievable, realistic and timed.

3.2 REQUESTS FOR INFORMATION AND INFORMATION NEEDS

Answering questions about what asset information is needed and why is in the fact that the same data and the similar information are often required for different purposes. Users often perceive only their own needs, which leads to a situation when different users attempt at developing their own information systems to meet their own information needs, which in turn leads to inconsistent information in practice. Therefore, before that question is answered, it needs to be determined who need asset information, to what purpose (why) and finally what information is needed by which user group.

3.2.1 Users of Asset Information

There is a wide range of asset information users spanning several levels of asset management decision-makers, from direct participants in a variety of asset management-related operational activities through to external users, such as organization's customers, partners, government and regulatory bodies, scientific institutions and professional organizations, etc.

Depending on their role and position, user groups require information that are different in their purpose and level of detail. However, regardless of the granularity in the required information, its consistency must be preserved in all use instances and both within or outside of the organization. In other words, information that is used at the lowest level of operational activities, it is necessary to conform to those used at higher tactical and strategic decision-making levels, i.e. that there exists so called "a single version of truth". Organizations that can provide and demonstrate a single flow of information are better equipped to respond to changes in business environment and new challenges.

Information required for the effective asset management can be grouped as follows:

- Strategic information - used by top management and key decision-makers;
- Tactical information - created and used by the technical planning managers;
- Operational information - created and used by operational and technical staff.

3.2.2 Requirements and Needs for Asset Information

Asset information is needed to support one or more business processes related to asset management. These processes may be, as mentioned earlier, on the strategic, tactical or operational levels.

However, before considering specific details about the information needed at particular management levels, it is vital to clarify why that information is needed by certain user group, in order to avoid the situation that information is required by virtue of information, meaning that information is an end in itself. It is useful to quantify the cost of ownership (collection, processing) of certain information, since in some situations it can be a key motivation for accepting or rejecting some information request. Cost estimate is achievable by joining inherent or estimated costs to a process of information collection, which is a sufficiently comprehensible way to quantify the need for information ownership.

The sources and the ultimate destinations of all business information are business that generate or use it. Participants in these business processes are users of information and the best way to get answers to why certain information is necessary or required is that each users that needs particular information provides explanation of the reasons for that need and relate it to the appropriate business process in which it emerges. Obviously, this implies means a good understanding of business processes, as well as the responsibility for their operation within an organization.

One of the methods for the collection of information requests is outlining business processes diagrams and then examining potential answers required for the key points of each of those business processes. Moreover, it is pragmatic to establish a team to collect precise information requests, taking into account team members' competencies, since for example, operational or technical managers should not define information needs for establishing a corporate strategy of an organization.

It is evident from the aforementioned that the entire process of collecting, reviewing and approving requests for information should be well organized and well executed, taking into account the needs and requirements of all interested users within an organization.

3.2.3 Required Information

After reviewing the needs and requirements of information users, it is feasible to proceed with defining the detailed information requirements specification. By its very nature, asset management necessitates information from different sources and varying level of details. For the purpose of adoption of realistic asset management plans, it is essential to provide information about the condition and performance of assets, which inter alia, includes the following information:

- Age of assets;
- Current condition of assets;
- Actual value of assets;
- Location of assets;
- Maintenance, repairs, and replacement records for assets ;
- Constructive and technical characteristics;
- Replacement and/or maintenance costs;
- Estimated remaining service life;
- Estimated usefulness of assets;
- Estimated failure risk;
- Relationships with other assets;
- Etc.

The information above is most often used for comparison (benchmarking) of assets condition and performance at some point in time and may be aggregated per some criteria to provide an overview of the overall system or its components condition and performance.

During the development of detailed specification of asset information requests, it is possible to be governed by the following general set of information:

- Physical data about assets;
- Asset location and spatial connections to other assets;
- Data about maintenance or asset replacement activities;
- Asset performance data;
- Asset condition data;
- Assets' financial data.

However, in addition to the detailed information needs specification, it is necessary to consider other aspects of required information, such as:

- Frequency of use of information – i.e. how often is a particular information needed;
- Asset characteristics particularities – i.e. necessary attributes of assets that are required for decision-making;
- The accuracy and precision of information – i.e. the extent to which inaccuracy or imprecision of asset information may be tolerated.

3.2.4 Classification of Information

The need for aggregation of asset information implies that it is desirable to envision and define the classification of assets according to established criteria and attributes during the activities of the evaluation of necessary and requested information. The classification if usually not one-dimensional, but hierarchical. Defining hierarchical asset classification established a consistent decision-making framework and it is usually reduced to the prioritization of assets according to their criticality for business operations.

Classification criteria affect the approach to information storing within asset management information system and also directly shape decision-making in asset management processes. Information classification may be based on function of assets or their type. For many business processes that manage infrastructure assets, classification may be broader and include location, age, risks, performance and service levels of assets.

3.3 COMPLETENESS AND QUALITY OF ASSET INFORMATION

The knowledge about what information we need, why it is needed, who is the information user and to what purpose, is still not sufficient to make asset management decisions with full confidence in their effectiveness. It is possible to own all necessary information, but that it is deficient – due to being incomplete, not sufficiently detailed, to have information that is not historically related or that information that does exist is not easily available. All of these are reasons to question ourselves regarding what information we currently own, in what form and the quality of that information.

3.3.1 Completeness and Availability of Asset Information

Activity of the assessment of information that we currently own, and that is in accordance with the previous requests for information, cannot be reduced only to "yes" or "no" answers. It is an iterative process that can return back to the information users and to a need to redefine needed information. One of the possible outcomes of assessment is the comprehension that the cost of information collection and storing is too high and that, as such, violates the fundamental "cost-benefit" principles. In these cases, it is necessary to redefine the needs and requirements for information, and then continue the process of assessment of the owned information.

During the assessment of whether the necessary information are available, the following facts need to be checked:

- Are the necessary data collected and/or stored at all?
- Are the necessary data complete?
- Are there sufficient and necessary data history?
- Are there relationships between different sets of collected data?
- Are the necessary data sufficiently readily accessible for use?

For all the data we own and for which the answers to previous questions are positive, it is necessary to continue with the assessment of their quality. For data or information to which some of the answers are negative, it is necessary to determine and resolve the underlying causes before proceeding with their quality assessment.

3.3.2 Information Quality

The quality of information is a key element of effective asset management. It is based on the fact that information may be available and even complete to some extent, but if there is not full confidence in accuracy of this information, its contribution in asset management decision-making is disputable. Without confidence in the accuracy of information, there is no effective asset management system.

Assessment of information quality is likely one of the most complex and time-demanding activities. It is based on a number of methods, which purpose is to answer the following:

- Unambiguity of data interpretation;
- Consistency of data;
- Accuracy of data;
- Integrity of data;
- Uniqueness of data.

Asset information quality assessment activity is not a one-time action – it is a continual process of monitoring the information. It involves people, processes and information systems that support asset information management. The result of assessment activity is identification of underlying causes of inadequate information quality - in fact, it is a deviation of current from the expected information, and (the activity) results in:

- Defining actions and plans to address the identified deficiencies;
- Impact assessment of the deficiencies to overall decision-making process;
- Risk assessment on the overall asset management system;
- Cost estimate to eliminate deficiencies.

A good practice dictates that measurable key performance indicators are established during the information quality assessment activity. For instance, indicators may be the extent of information or a set of information is complete, or the extent to which particular information is accurate. Since we are considering a continuous process of information quality assessment that is reiterated in predetermined intervals, the established key performance indicators will be helpful in determining the causes of deficiencies or shortcomings.

3.4 ASSET INFORMATION MANAGEMENT

Asset information come from various sources from within or outside of an organization and it is necessary to assure their manageability and sustainability, taking into account all the aforementioned regarding the information quality, availability, completeness, accuracy, etc. Although the information management is a broader aspect and includes processes, procedures, people and technology in a more narrow sense of the term generally refers to the information systems for information management.

3.4.1 Asset Management Information Systems

Asset management information systems are applications used for collecting, storing, processing and analysis of asset information.

There is no standard defining information systems that yield the best results in practice. In smaller organizations, an information system may be based on paper documents and spreadsheets, while larger organizations usually implement automated, information systems supported by computing and information technologies.

Computer-based information systems vary in complexity and integration. In the upper segment, there are complex, integrated information systems, then we have specialized applications that are integrated to a greater or lesser extent in cohesive, integrated information systems, and finally there are individual applications or various analytical spreadsheet-based software tools. All solutions are generally used for storing and managing asset information and in support to the strategic, tactical and operational asset management decision-making.

The functionalities that such software tools should support include:

- Efficient and systematic collection, storing, searching, management, analysis and reporting of asset information;
- Efficient integration and management of various aspects of assets' life-cycle by integrating various business processes and associated data;
- Efficient monitoring and management of information related to projects, work orders and plans, aiming to improve operational efficiency within processes related to planning, execution and coordination of activities pertinent to maintenance of assets;
- Supporting coordination and optimization of the asset maintenance budget allocation and distribution according to the priorities and risks associated with the degradation of assets performance.

Typical information systems for managing asset information include:

- Asset register, including detailed asset information that is of interest for management within an organization;
- Information system for planning and monitoring asset maintenance-related activities
- Geographic Information Systems, for storing geo-referenced asset data, such as their geographic location or other spatial data;
- Information systems for monitoring and management of logistical information associated with spare parts and equipment;
- Process, telemetric and SCADA systems, for recording and storing real-time asset performance information;
- Information systems for storing and tracking information on the monitoring of condition and key performance indicators, in order to support forecasting of asset failures;
- Information systems facilitating decision support in strategic planning activities, such as investment modelling and other similar activities.

Throughout the asset life-cycle, various roles and activities within an organization express interest for asset information and require representation and managing of asset information in different formats. It is therefore vital to be able to leverage robust reporting systems that are integrated within implemented asset information systems.

3.4.2 Implementation of Information Systems

Even in circumstances when an organization does not have sophisticated information systems, it is possible that adequate asset information exists within the organization and they may be retrieved from different sources for the asset management purpose. When an information system is being implemented, all such sources of information must be verified to establish the initial asset information database.

In the previous chapters discussed what information is necessary for adequate asset management. During information systems implementation, it is necessary to evaluate the cost-efficiency of information collection and storage, obviously including identifying the alternatives for collection and storing only information indispensable for fulfilment of business goals. Differences between requested information and those derived from “cost-benefit-risk” assessment method, must be considered in advance and make appropriate decisions.

Beyond technological, the decisions include human resources and procedural aspects. While small changes in asset management activities suffice to accomplish improved effectiveness in some situations, the motivation, knowledge and staff training are key aspects of overcoming information gaps in others.

Organizations that are executing intensive asset management activities, especially if assets are geographically distributed, may significantly benefit, in terms of establishment of effective asset management system at large, by adoption of technologies, or undertaking modification of existing technologies, when it makes available and facilitates mechanisms for automatic collection and storage of asset information. Nevertheless, an assessment should be carried out in order to deduce which information systems for asset management are appropriate for the organization, which can be implemented, as well as what level of integration of planned and current information systems is necessary.

Conventional asset management information system comprises two principal components: relational database with asset data, and software tools for analysis and decision support. Inputs and outputs to the system are standardized, such as manual data entry forms or pre-defined reports (automatically generated or on-demand) with processed data from the system.

More recent versions include interaction and some data aspect’s representation with other systems interfaces. Most prominent example is visualization of assets spatial component in Geographic Information Systems (GIS), but other functionalities include: asset performance analysis and water system modelling, asset life-cycle cost management, planning investments and their impacts, maintenance management, customer support, etc.

In terms of their coverage of asset management scope, software can be categorized as general purpose and asset specific software. The first category executes more generic functionalities so they must be adapted and customized for the purpose. Asset-specific software have more concrete purpose, which is accomplished through implemented built-in facilities in support of more narrow scope of organization assets types.

General-purpose software mainly manages asset information related to their core properties attributes, financial aspect, work management and scheduling, as well as budget and procurement management. However, their value is increased if they can interface to other systems that complement its functionalities (e.g. ERP, GIS, CAD) and comprise corporate information system with added-value compared to a set of distinct systems.

Asset-specific software has emerged in the last decade and manages sub-sets of assets they are designed to support. Their purposes vary and some examples include management of water distribution systems and sewage/stormwater systems. As general purpose systems, they also normally use RDBMS for information storage and may include GIS capabilities or support external GIS systems. Their data management functionality is often supplemented by support for asset performance and condition surveillance and benchmarking. As significant examples, Engineered Management Systems (EMS) and remote monitoring systems are further elaborated in the remainder of this document.

3.4.2.1 General-purpose software solutions for asset management

A variety of general-purpose information systems for asset management are used by organizations. For asset management purposes, the most important of these systems are financial and enterprise data management systems, GIS, computerized maintenance management systems and customer and billing information system.

Most commonly used information systems that comprise core of support to asset-related operational activities and business processes in organizations are:

1. **Enterprise Resource Planning System (ERP)** – Information systems for maintaining and analysis of General Accounting Ledger, tracking accounts payable/receivable, budgeting and fixed assets depreciation. They usually include: modules for end-to-end spare parts supplies and expendables inventory (from their procurement to consumption); human resources management; payroll; work-time tracking and similar.
2. **Customer Information System (CIS)** – Systems for gathering, management and analysis of services rendered to consumers and relevant consumed quantities (e.g. water consumption). They typically facilitate customer invoicing and track billing. In ideal environments they are supported by meter reading systems of varying degree of automation.
3. **Computerized Maintenance Management System (CMMS)** – Systems designed to handle planning, logging and monitoring of preventive and corrective maintenance of organization's assets. They undertake collection, monitoring and analysis of information related to asset condition and performance levels.
4. **Geospatial Information System (GIS)** – information systems for visual presentation and analysis of assets on geo-referenced maps. GIS usually assist modelling processes and maintenance of assets. Another significance is their potential in decision-making and assisting in communicating data with spatial component.

These systems support most of key required functionalities necessary for asset management role in organization.

Each of them have a role and significance and fundamentally contribute to in asset management in two aspects: firstly, by gathering and storing data to empower a better understanding of the state of affairs to further foster governance and informed managerial decision making; and secondly, to enable improved efficiency of business processes, to make them more agile and affordable, yielding better results for customers.

A key concept for majority of identified core information systems is that each of them generates specific sets of data to benefit numerous business processes and roles within the companies exploiting them. However, the true benefits and fully potential is reached when they are used in synergy, as a single entity in which data flows predictably, in a clearly defined manner, through the system of interdependent entities.

Nevertheless, it is unfortunately common that each system has its own database, segregating the global parameters and properties of assets for specific purposes of the designed systems. That produces obstacles for company as a whole and interferes with processes of inevitable transparency and accessibility on corporate level for the purposes of management and exchange of information. Therefore, significant efforts need to be undertaken in integrating the relevant information systems for their prolific exploitation.

The remainder of this section reviews the "core" general-purpose information systems used in most of companies.

3.4.2.2 Enterprise Resource Planning Systems (ERPs)

Enterprise resource planning systems are being used in organizations for decades aiming to encompass essential business functions in a single software product. Initially, they were primarily intended for companies that needed to execute integrated supply chain processes, providing services, goods manufacturing or maintenance-related business roles, but were later extended with more functionalities, such as: finance, financial operations, human resources management and other modules.

At present, ERP systems are usually put in operation to manage several business functions:

- Finance and Accounting (e.g.: General Ledger accounting, Accounts Payable/Receivable, Financial Planning, Reporting & Analysis, Fixed Asset Accounting, Investments, Human Resources Management, Payroll, etc.),
- Supply Chain (Procurement, Inventory Management)
- Key Performance Indicator Measures & Reporting.

ERP systems employ significant functional integration between the listed business functions, for instance, between inventory tracking, procurement and monitoring of suppliers. It is possible for system users to leverage that functional integration of an ERP system to execute their business processes easier, more efficiently and in a much more consistent manner. Apart from that, inherent integrability of an ERP system is less costly solution, as it requires no additional cost for integration of individual software products.

In practice, an alternative to ERP systems is the approach known as “Best of Breed”. Instead of a unique, single-vendor ERP solution, it implies procuring only a part of vendor’s ERP and only modules that best support its business processes. Missing modules and functionalities are supplemented with software from different vendors (such as modules of a different vendor). Often, separate software products are implemented for finance and human resources management roles, while the asset management functionality is often bundled with software for Computerized Maintenance Management System. These three separate systems are being integrated through further process and additional custom software components. The benefit of this approach is that the resulting integrated system may better suit the specific needs of organization.

Experience has shown that implementation of ERP necessitates changes in existing business processes of organization to avoid the common pitfalls causing implementation failures. That primarily relates to a good understanding of their business strategy and distinctiveness of the organizations’ business model before the ERP implementation has commenced.

Accordingly, non-integrated solutions have somewhat accomplished short-time needs, but have also presented a significant challenge in attempts to ensure consistent reporting mechanism and so called “single version of truth” (SVOT, an IT concept in business management promoting a single database or synchronized database replicas across an organization). Integrated products accomplished significantly quicker and easier reporting procedures, as well as consistent and standardized access to relevant information.

Preference in using integrated ERP product is with large organizations, which have sufficient resources and adequate expertize for successful implementation. However, many organizations still prefer a combination and selection of “Best of Breed” applications as opposed to ERP from a single vendor, despite the fact that they require integration before they may operate as a cohesive, uniform information system.

3.4.2.3 Customer Information System (CIS)

The Customer Information System (CIS) with billing support functionality is one of the essential information systems in most utility organizations. It incorporates many customer and service related aspects of business ranging from managing customer accounts, invoicing, collecting customers' requests and service orders as well as their processing.

In practice, apart from if basic purpose of customer billing and invoicing, many well-designed CISs provide further benefits to organizations:

- Unique, comprehensive view of customers. Customer information are particularly significant for organizations as they facilitate effective collection/revenue management practices.
- Support launching customer portals to enable more simple and transparent access of customers to information of their interest: overviewing consumption, viewing and printing invoices and billing history, modifying their account information, report problems and submit service requests, etc.
- Reading and recording consumption with different degrees of automation. Possible implementations vary accordingly:
    - Digital meter reading (e.g. with hand-held devices in the field), with the benefit of reading the meter with no customer premises access. That somewhat reduces the amount of field work and the number of appointments, but it also reduces the possibility of a human error while reading analogue meters.
    - AMR, which is a fully automated, centralized meter reading (e.g. via a radio link) and that can immediately be used as basis for invoicing. It significantly reduces operational costs of manual labour (manual meter reading fieldwork), but also supports more agile consumption data collection for more efficient charges collection, as well as better support to planning and decision making.

However, it is important to mention that both system types require significant investments, both in terms of infrastructure and equipment being put to use, as well as increased and more complex technical expertise needed for operation, support and maintenance of such systems.

A large number of implemented Customer Information Systems is currently in use, and their basic characteristic is that they are increasingly web-based. Efficient CIS imposed integration with other information systems, so it is common that it has more interfaces and integration points compared to other information systems.

3.4.2.4 Computerized Maintenance Management Systems

A Computerized Maintenance Management System (CMMS) is an application to track assets and maintenance history and costs.

Its basic characteristics are that it:

- Provides gathering and processing of asset data, related maintenance costs in support asset management decision making, supporting the overall asset management programme.
- Handles information related to priorities, physical condition, depreciation costs and maintenance of physical assets.
- Facilitates generating and tracking of work orders and allocation of resources.
- Centralizes processes of preventive maintenance and its scheduling.
- Supports integration with GIS systems to account for spatial information of assets and relevant geospatial analysis.

- Enables integration with mobile devices, which makes possible access to information from the field.

CMMS are often deployed as part of larger enterprise solutions. Regardless of the mode of their implementation, most of CMMSs comprises several major modules covering functionalities such as: Asset register, Work and Maintenance management, Purchasing and Materials Expenditure and Invoice matching. Furthermore, it is also well supported by functionalities that support mobile access for maintenance workforce operations in the field, to efficiently and instantly track work orders and their life-cycle.

In addition to that, there are strong ties between the functions of CMMS and various other systems, including:

- Geographic Information System (GIS) – mapping and geospatial analysis of distributed organization assets, many of which are managed in a CMMS
- ERP – management of the "supply chain", in which the ERP (financial) system may be the system of record for inventory and purchasing of maintenance spare parts and supplies.
- Customer Information System (CIS) or more specifically Customer Relationship Management System (CRM) – management of customer inquiries, complaints and service orders, typically coordinated with maintenance teams and the CMMS work order system for certain types of maintenance activities.

A CMMS supports some of key processes within organization, providing key benefits to the asset management role of a organization:

- Assisting in accounting for **total cost of ownership of assets** spanning entire life cycle through maintenance records. They support accounting for quantitative part of supply chain management (work orders, labour, outsourced services, material, spare parts, etc.) and its optimization for improved resilience through supplementary processes of organization.
- **Budgeting** and planning of expenditure. That is particularly useful in preventive maintenance, but also in corrective maintenance budgeting, since historical records provide input for risk assessment, which in turn supports budgeting and resource allocation.

Many of the CMMS applications are web-based, whereas the earlier technologies were based on client-server architectures. Early CMMS required customization-to work with GIS, but modern iterations have built-in integration as a norm.

3.4.2.5 Geospatial Information Systems (GIS)

Geospatial Information Systems, as systems for management of spatial data and associated attributes is increasingly important application in many utility organizations. The reason for this is the fact that most of the assets are geographically distributed and that the information about the assets are often stored in diverse forms and separate data repositories and that a need exists to integrate them.

Assigning a spatial component to data, as the principal objective of GIS in such organizations from the asset management standpoint, enables data analysis and making informed operational and strategic decisions.

Moreover, as GIS can assign spatial component to any data, most of its use-value applies to asset geo-referencing and assigning asset properties, but also assisting in problem locating and logging work and maintenance of assets. That benefits far beyond the instinctive perception of GIS as a tool to display the maps, since it considerably simplifies corrective maintenance and directly supports decision-making, implementing investment strategy and preventive maintenance.

Nevertheless, the mapping features and outputs are also of paramount importance for field workers during the interventions and maintenance. Adequate mapping information noticeably reduces time to location and diagnostics during the repairs (as much as a quarter of work order time is quoted as benefit). In that regard, GIS naturally interfaces well with a CMMS, expanding its functionalities by geo-referencing the asset data.

In addition to the benefits above, properly implemented GIS in organizations plays an important role in the analysis of parameters of asset network, as well as the evaluation and planning of improvements of performance and service levels.

Integration of GIS with other information systems in organizations can be realized in several modes, which principally relate to that in which system the asset information will be kept. One approach is to implement GIS and CMMS as unified information system, whereas there may be some sort of integration with the other information systems. The alternative approach is to procure and implement GIS, CMMS, ERP and other information system as independent components that may have partly or fully defined interfaces to each other. The disadvantage of the former is that the separate storage of individual views of an asset breaks the integration of the overall enterprise system, meaning that all components operate independently to some extent, making it difficult to ascertain a holistic view of assets.

3.4.3 Asset-specific software solutions for asset management

In practice, a range of asset-specific software exists for broader purpose of asset management, such as:

- Supervisory Control and Data Acquisition System (SCADA) – Systems aimed at automatization and remote surveillance and control in real time
- Capital Program Management Software (CPMS) – Systems intended for planning, monitoring and control of capital projects related asset management
- Engineered Management Systems (EMS) – Information systems for evaluation of asset conditions in terms of performance levels and tool for assessment of requirements for maintenance

An example of the asset specific software solutions are Engineered Management Systems (EMS), which assist in evaluation of asset condition, estimate maintenance requirements through performance criteria, including consideration of maintenance operations prioritization.

These systems embraced a methodology for estimation and measurement of performance level of infrastructure assets, which assumes using infrastructure asset condition data to derive a Condition Index (CI) and classifying it within predefined rating criteria. Index therefore suggests asset components performance level, which is in turn used as an input for investments in maintenance work.

Many organizations dedicate resources to undertake development of their own, in-house software solutions, in majority by customization of some more general purpose tools. By such approach, widely-available commercial software is used to establish a platform that is further adapted for asset management purposes (notable examples being spreadsheets, CAD and GIS applications and relational databases - RDBMS). In time, these systems have matured to cover several more asset-specific processes, e.g.: work management and maintenance, procurement etc.

One more noteworthy example is asset remote monitoring accomplished by a range of sensors, meter and Supervisory Control and Data Acquisition systems (SCADA). They are considered legacy IT systems, but play an important role in operational management (e.g. can raise alarms to staff in case of important events or problems so that corrective maintenance can be carried out).

Moreover, they also provide important feedback to performance measurement that can be further analysed. For example, information systems dealing with maintenance planning can assess that information, compare against expected levels and other similar assets to support decision-making of business roles dealing with investments and maintenance planning. Historical information also contributes in strengthening both technical and business processes within the organization by providing knowledge base and record of auditable information. Overall, such systems and their information can also contribute to improving capabilities for improve efficiency of systems through system modelling process and assessing effectiveness of investment and maintenance policies.

Integration of remote monitoring systems to overall asset management processes and relevant other information systems therefore helps deepen the knowledge on assets performance impacting organizations’ ability to improve return on assets.

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ANNEX: GUIDING QUESTIONS FOR SELF-ASSESSMENT OF AM PRACTITIONERS

Asset Management System

1. Is the purpose of AM well understood among decision-makers?
2. Have the decision-makers appointed responsible senior staff for establishment and implementation of AM?
3. Has the AM senior staff communicated the importance of meeting AM requirements to all relevant staff?
4. Has the AM senior staff identified competency requirements from the staff for meeting AM requirements?
5. Has the AM senior staff planned training requirements to achieve the competences?
6. Are all staff aware of their roles and responsibilities within the AM system?
7. What written documentation (protocols/procedures) have been developed to support AM system and its elements?
8. Have the decision-makers identified the expectation of stakeholders?
9. Is the scope of AM system defined?
10. Is AM policy documented, adopted and communicated to all stakeholders?
11. Does the AM policy align with municipal strategic/development plan?
12. Does the AM policy demonstrate a commitment to continual improvement in asset management?
13. How do decision-makers insure that the AM policy is periodically reviewed?
14. Is AM strategy aligned with AM policy?
15. Is AM strategy communicated to all stakeholders?
16. Does the AM strategy takes into account of the assets’ condition and performance assessment?
17. Does the AM strategy takes into account asset related risks?
18. Does the AM strategy take into account present problems related to asset’s condition and performance?
19. Does the AM strategy state the desired level of service?
20. How do decision-makers insure that the AM strategy is periodically reviewed?
21. How do decision-makers establish their AM objectives?
22. Are AM objectives measurable?
23. Do AM objectives take into account legal, regulatory, stakeholder requirements?
24. Are AM objectives communicated to all stakeholders?
25. Do AM objectives demonstrate a commitment to continual improvement of utility service?

26. Does the AM plan identify activities required to optimize costs, risks and performance?
27. Is AM plan communicated to relevant staff involved in plan's delivery?
28. Are designated responsibilities for its delivery documented in AM plan?
29. How does the organization collect asset data?
30. Does the organization have forms for collection of data?
31. Is there established assets' condition and performance grading criteria?
32. Is there established assets' criticality criteria?
33. Is there established a life-cycle managements of assets?
34. Are operation and maintenance procedures established?
35. How is a need for appropriate preventive actions to avoid failures determined?
36. Does the organization carried out investigation of asset failure?
37. How does the organization plan/schedule maintenance, repair, rehabilitation and replacement of assets?
38. Is there a written procedure for monitoring AM system performance?
39. Are responsibilities for monitoring clearly defined?
40. Are monitoring criteria, scope and methods defined?

Asset Information Management

1. Who are the users of asset information?
2. Are there clearly defined requirements for asset information from various user groups?
3. Have the requirements been communicated / specified?
4. Do the information requirements of various user groups have a purpose, are they justifiable and are they in accordance with the business processes?
5. Are the information requirements and outputs of a delivery process clearly defined?
6. Do the information requirements vary in level of details, and to what extent?
7. What of those information (from information requests) are already owned and available?
8. Is there one clear home for this data?
9. Is the process for capturing the data documented & understood?
10. Is the process for capturing the data „straight forward‟ to follow?
11. Is the process open to interpretation?
12. Is human knowledge an essential part of the process?
13. Do people understand the importance of the data?
14. Are issues of responsibility clear for provision and maintenance of information?
15. Is there a mechanism for assuring a unique, consistent view on information, regardless of their levels of detail and use?
16. Is it easy to input / submit data?
17. Is it easy to retrieve data?

18. Is it easy for users to interpret data?
19. Is it easy to relate one data set to another to produce the intelligence needed?
20. Are deviations between available and required information identified?
21. Is the gap in requirements small, so that it can be covered by small changes from present processes?
22. Does the gap arise from the data itself, the way it is processed or who requires it?
23. What are the costs and benefits of providing information that is currently not available?
24. Would new data collection technology help?
25. What are the technological limitations associated with making available the information that is currently not available?
26. What are the risks and their level derived from unavailability of required information?
27. Is there a culture of developing „local solutions‟ at the expense of corporate solutions?
28. Is the quality of information being assessed?
29. Is there awareness of the risks of inaccuracies and imprecision of information?
30. Are the information quality and availability being monitored?
31. Can we measure performance for data roles?
32. What data collection and management systems are suitable and available, and what degree of integration is appropriate?
33. What do similar organisations (in this or a parallel sector) do?
34. In the light of the possible options, is it necessary to reconsider the level of data to be collected and processed?
35. Does the asset information system conform to standards specified by the business?
36. Will another technological development in the next year or two be a more effective and cost-effective solution?
37. Is this technology proven, or might it introduce an unacceptable risk?
38. Technology has the potential to produce vast volumes of data. Do we need this volume and can we handle it?
39. Is there established asset information management strategy?
40. Are the roles and responsibilities associated with the asset information management strategy?
41. Does the Asset Information Management Strategy include key decisions and information necessary for their adoption?
42. Does the Asset Information Management Strategy include interrelationships with business processes relevant to asset management?
43. Does the Asset Information Management Strategy include proposed approach to defining information requests, which should include the cost of providing asset information?

44. Does the Asset Information Management Strategy include flow of information, system interfaces and logical data models?
45. Does the Asset Information Management Strategy include organization of information and data management?
46. Does the Asset Information Management Strategy include costs, benefits, and timing of activities to accomplish necessary improvements in asset information management?
47. Does the Asset Information Management Strategy includes the key asset information system functionalities that need to be supported or that are mandated?
48. Does the Asset Information Management Strategy include requirements for the essential, most important asset information systems?
49. Does the Asset Information Management Strategy includes elaboration of various information systems integration (both the existing and projected)?
50. Does the Asset Information Management Strategy include strategy for migration of existing information systems to newly introduced information systems?
51. Does the asset information management strategy include specific, measurable, achievable, realistic and timed objectives pertinent to proposed improvements to the asset information management?