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Development of Total Solution and Program for Asset Management in Water Supply Network

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Abstract

A total solution for water supply network asset management was established by amassing the entire water supply network asset management process, such as inventory database development to technology inspection, remaining service life prediction, LoS, life cycle cost and risk analysis and improved output calculation. The total solution was configured in five steps on the basis of the general seven-step asset management procedure with consideration given to the performance by step investigated in this research project. Separate programs were developed for each step of the total solution. In addition, the functions of the program were divided into parts so that asset managers using this program can conveniently administer the asset management by implementing the functions in sequence.

Keywords: Water Supply Network, Asset Management, Inventory Database, Level of Service, Life Cycle Cost

INTRODUCTION

Compared to other SOC facilities, the water supply network involves a greater level of difficulty in operation and maintenance due to their characteristic of being installed underground. In particular, aging of pipelines in large cities, which were designed and installed in the early days of city construction, has led to a number of issues, such as defective water outflow, leakages, increased complaints and functional deterioration. The inability to identify such issues further aggravates the situation. Therefore, the necessity for establishing a water supply network management system by implementing a systemized asset management concept, asset value management through repair and maintenance and long-term budget management is higher than of other facilities.

For asset management in SOC including the water supply network, a number of studies have been conducted in advanced countries including Australia, the U.K. and the U.S. In the advanced countries, most SOC facilities were built after the Second World War and aging of the facilities resulted in a rapid increase in maintenance costs during the 1980s. In the 1990s, the percentage of maintenance costs rose up to as much as 40% of the total construction budget. As such, the surging cost of facility maintenance caused considerable damage to the national budget. As a countermeasure, these countries started introducing asset assessment or management techniques in the mid 1990s and have since been studying and applying detailed implementation plans.

Korea needs to develop a total asset management solution that is suitable to its current conditions by examining water supply network asset management systems adopted in the advanced countries. Therefore, in this study, a water supply network asset management procedure is introduced as of the following.

MATERIALS AND METHODS

Water Supply Network Asset Management Procedures

Based on the result of examination on the asset management systems of advanced foreign countries, a water supply network asset management procedure was configured in seven steps.

① Develop inventory DB

② Investigate operation data, conduct technology inspection

③ Predict remaining service life

④ Analyze LoS

⑤ Analyze risk and improvement demand

⑥ Establish optimal investment plan

⑦ Establish financial plan and asset management basic plan

Classification of Asset Management Procedures

Considering the varying conditions and technological standards of water supply service operators in Korea, the seven-step procedure was divided into "basic asset management" and "detailed asset management."

The first method is for the basic asset management. This method can be used when a water supply service operator is not capable of implementing the entire procedure with its service operation standards and conditions. Basic asset management is carried out in four out of the seven steps of the water supply network assessment management procedure. The four steps are ① inventory DB development, ② operation data investigation and technology inspection (diagnosis and assessment), ⑤ improvement demand analysis and ⑦ financial plan and asset management basic plan establishment. In the basic asset management, the asset status is diagnosed and assessed based on the asset's statutory service life as prescribed by the Local Public Enterprises Act. Therefore, it is considered ideal to exclude the four steps of, ③ remaining service life prediction, ④ LoS analysis, ⑤ risk analysis and ⑥ optimal investment plan establishment.

The second method is for the detailed asset management. In detailed asset management, all of the four steps defined by the researchers are implemented. The remaining service life of an asset is predicted and the LoS is analyzed, which are not performed in the basic asset management. Then, based on the results, risk analysis and improvement demand analysis are conducted. For the purpose of establishing a highly reliable financial plan, it would be proper to carry out detailed asset management. However, both the basic or detailed asset management method is selected depending on the regional and financial conditions concerned and insufficient data are supplemented so as to improve reliability.

RESULTS AND DISCUSSION

Development of Total Solution for Asset Management in Water Supply Network

Up to step five of the seven-step procedure was categorized for application to the scope of the total solution of water supply network asset management (Refer to [Table 1] and [Fig. 1].).

Table 1. Five Steps of Water Supply Network Asset Management Total Solution

Level	Purpose	Contents
1	Develop inventory DB	· Develop a database for the list of all assets owned by the water supply service operator · Standardize (name) and stratify assets
2	Investigate operation data and conduct technology inspection (diagnosis and assessment)	· Reflect results of investigation on accident and operation records of facilities in the DB · Analyze LCC of each asset based on the DB
3	Predict remaining service life	· Develop basic remaining service life prediction method based on the statutory service life · Predict remaining service life based on the investigated operation data (product life cycle, damaged model)
4	Analyze LoS	· Analyze LoS for LoS setting · Adjust balance among services required by consumers, cost for providing the services, available services and risks caused by the services
5	Analyze risk and improvement demand	· Analyze improvement priorities through risk estimation by water supply pipeline · Examine improvement time of each facility considering importance and investment priority of the assets · Predict assets for improvement based on the results of remaining service life prediction, risk analysis and LoS analysis

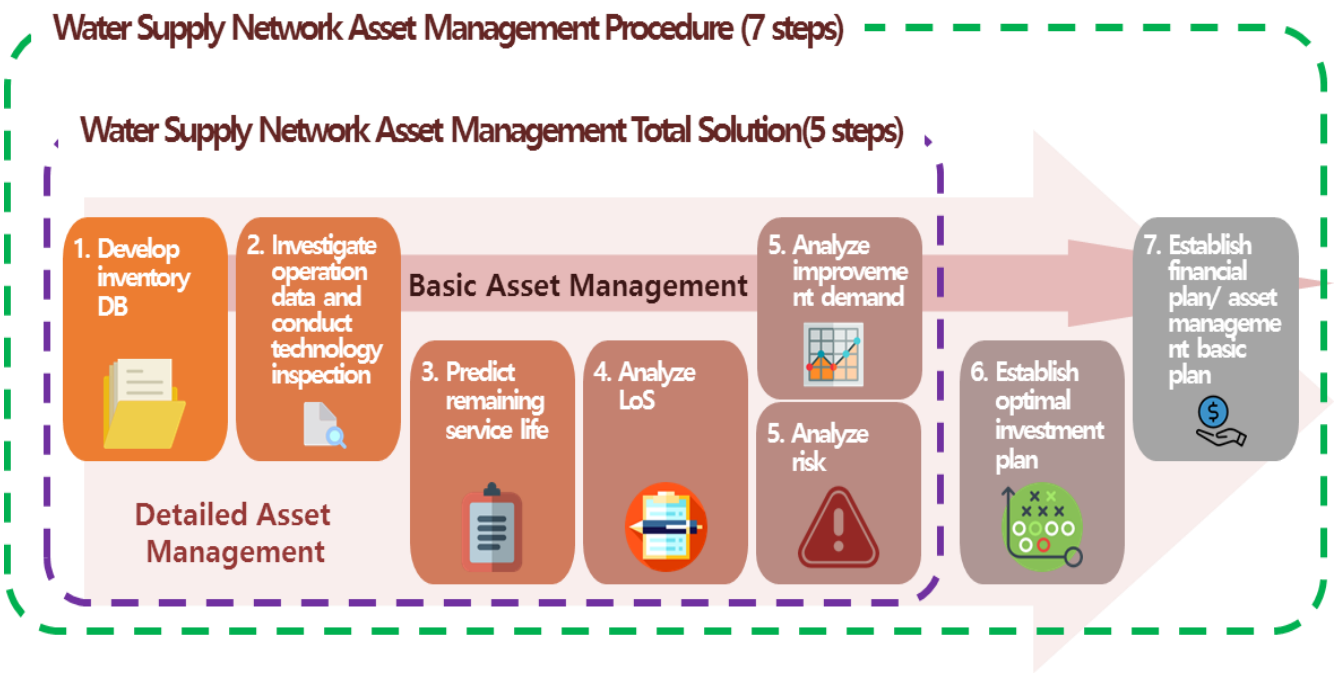

Figure 1. Water Supply Network Asset Management Procedure (seven steps) and Total Solution (five steps)

Development of Water Supply Network Asset Management Program

The program for asset management in the water supply network was designed on the basis of the previously explained total solution for water supply network asset management. Divided into five individual programs, this program has been developed with a goal to support decision making processes necessary in the implementation of the total solution for water supply network asset management. The program users build a list of assets for the water supply network under their management, conduct remaining service life prediction and LoS/ LCC/ risk analysis, and thus ultimately secure a foundation for analyzing improvement demands for their facilities.

Table 2. Key Functions of Water Supply Network Program

Level	Program	Function
1	Integrated Inventory DB	Standardize (name) and stratify assets Enter basic details, such as year of installation, pipe type and pipe diameter, by asset Enter inspection, cleaning, renewal and replacement records by asset Check list and history of assets
2	ATI (asset technology inspection)	Enter result of expert's assessment and service life by asset Predict remaining service life using a model for old pipe decisions
3	Analyze LoS (level of service)	Conduct assessment by experts' group and set weight by LoS assessment item Investigate supplier/ user group satisfaction by LoS assessment item and calculate LoS by item through gap analysis
4	LCC (life cycle cost) analysis	Calculate LCC of assets
5	Risk analysis	Estimate risks associated with assets

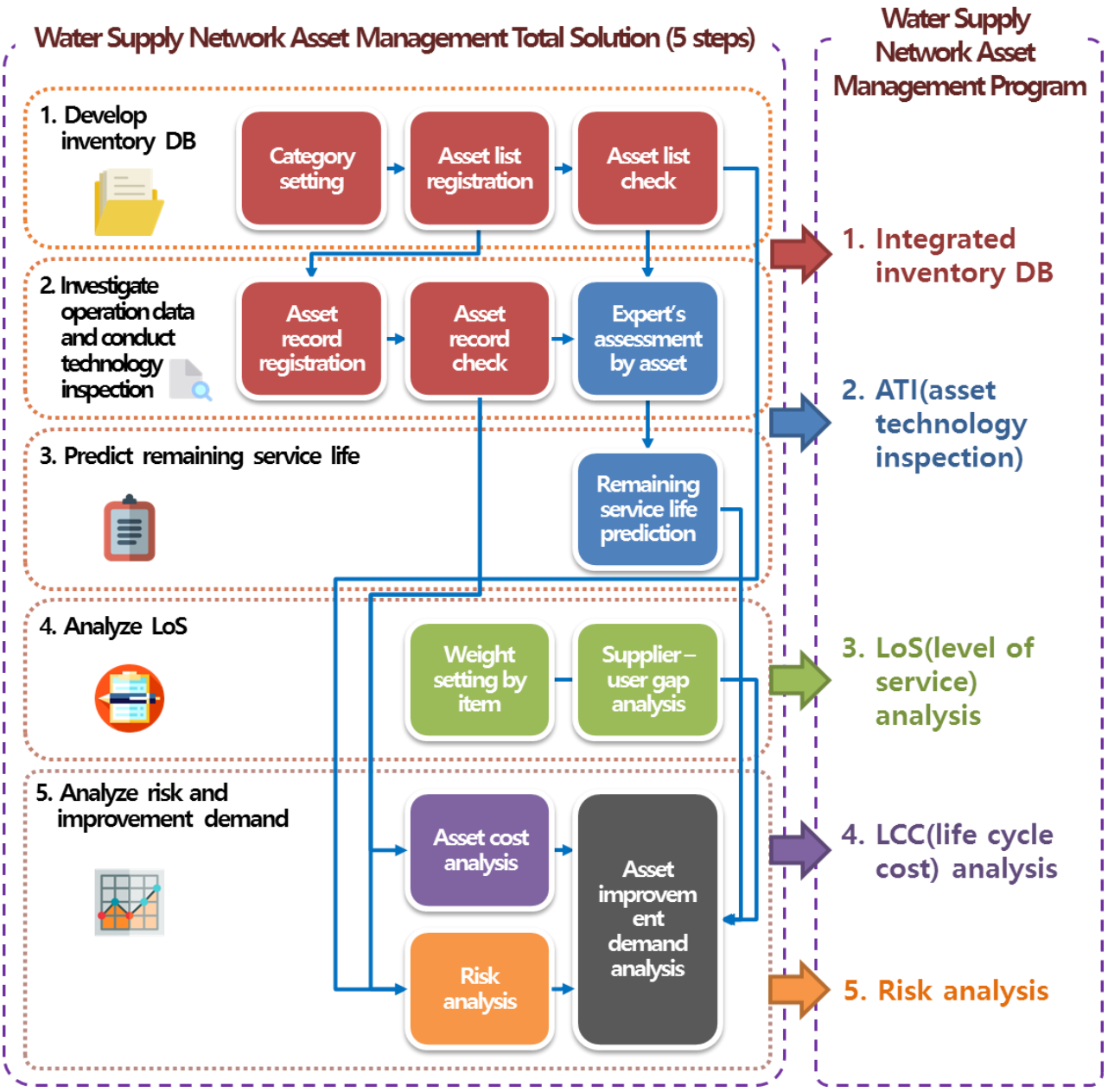

Figure 2. Water Supply Network Asset Management Program Configuration

Integrated Inventory DB. Water supply network inventory offers a list of detailed asset objects comprising each facility of the water supply network and the basic information of each asset object. In other words, the water supply network inventory DB is comprised of a set of such data. Therefore, the water supply network inventory DB establishment can be defined as a series of processes to unify information by eliminating the redundancy of information included in the list of detailed asset objects comprising the water supply network and the set of basic information of the objects, to structure and save the unified information, and thus to improve the efficiency of data search, processing and utilization. This study established the inventory DB standard system and developed the program after collecting the data needed to build the inventory DB for property management of water supply network. It then developed the 5-level inventory DB standard system by supplementing the standard system and enhancing the program. The integrated inventory DB program provided the field data needed for technology diagnosis, remaining life prediction, LoS analysis, LCC analysis, risk analysis, and improvement demand estimation. The scope of the integrated inventory DB development program includes inventory DB development, which is step 1 of the total solution, and asset record management, which is a part of operation data investigation and technology inspection, step 2 of the total solution.

Table 3. Functions of Integrated Inventory Development Program by Part

Part	Function
Login	Login screen to verify the authority for program access
Category	Categorize pipeline types into levels and designate items for each level so that management is carried out for items connected to each level
Asset registration and record management	Register pipeline information and manage pipeline records
Asset and record search	Search the saved pipeline information and records

Asset Technology Inspection (ATI). Water supply network technology inspection and remaining service life prediction are carried out for the purpose of inspecting current conditions of each water supply network facility including pipelines, and thus selecting the time and method of improvement. The method and scope of technology inspection and remaining service life prediction vary by researcher. Accordingly, the volume and format of data investigated are different by water supply service operator in each local government and it is realistically unfeasible to integrate them. Therefore, This program has been configured to enter experts' assessment result in place of experts' assessment for technology inspection in step 2 of the total solution, which is operational data investigation and technology inspection. In addition, remaining service life prediction by asset based on the technology inspection result, step 3 of the total solution, is carried out concurrently with experts' assessment.

Table 4. Functions of ATI Program by Part

Part	Function
Asset list assessment by experts' group	Display available service life calculated on the basis of ATI result
Remaining service life prediction	Display remaining service life predicted on the basis of ATI result and the estimated improvement year

LoS Analysis. Level of service (LoS) refers to the quality defined for a certain area of service. From the user's standpoint, LoS is about how a customer is provided with the service and what the customer requires from the service. From the supplier's standpoint, it is about how an organization provides the service. In asset management, LoS is a strategic goal and a declaration that is agreed upon among users. It not only is a major driving engine for a business, but also affects the overall asset management decision-making process. The AHP analysis identified the service level items and set the evaluation indices that were not available for the water supply network, and we were able to compare the service satisfactions between the users and the suppliers through the five identified items and 15 evaluation indices as a result. This program was developed for "LoS analysis," step 4 of the total solution.

Table 5. Functions of LoS Analysis Program by Part

Part	Function
LoS	Check satisfaction level based on the result of gap analysis between the level of service provided by suppliers and the level of service required by users
	Set weights by item based on the experts' group assessment

LCC Analysis. Life cycle cost (LCC) refers to all costs incurred during the service life of a structure or a system using the structure. From user's standpoint, it is a technique to assess the economic value of a structure through equivalent conversion of various critical cost items within the structure's economic life by using cost integration methods, such as a present value method or annual value method. In this study, we developed the model to calculate the enhancement cost and quantity to enable managing the water supply network economically by minimizing the cost of maintaining the facilities. We built the table for each year and calculated the cost for each step and usage to calculate the annual enhancement cost and quantity. We divided the cost into initial installation cost, maintenance cost, and disposal and replacement cost regarding steps and divided the facilities into the conveyance, transmission, distribution, and supply. In this program, it was developed for LCC analysis, one of the methods for improvement demand analysis, in step 5 of the total solution, which is risk analysis and improvement demand analysis.

Table 6. Functions of LCC Analysis Program by Part

Part	Function
LCC input	Select assets for LCC calculation
	Calculate LCC by step considering discount rate and service period
LCC calculation result	Display LCC calculation results for assets completed of LCC input
Graph by LCC element	Display LCC calculation results by asset type, operation type, component and cost item
Graph by LCC period	Calculate cost by period in comparison to the reference year and accumulated costs
	Display graphs of cost fluctuations by period according to data type

Risk Analysis. Risk analysis is to calculate the degree of risk, such as damage or breakdown, of an asset in order to calculate the improvement demand and to digitize the calculated value by linking it to the importance of each asset. In general, the risk of an SOC facility is expressed as the product of the consequence of failure with the probability of failure. The measuring indices to digitize the consequence of failure and probability of failure must be selected considering the characteristics and operating environments of each SOC facility. This study developed the risk analysis model based on the DB of damage history of domestic water supply network, analyzed the risks of water supply network in district Y using the model, and indicated the risk level of each facility in A to D. The result will be the reference data for checking the detailed problems of water supply network and making decision on improvement. In this program, it was developed for the purpose of risk analysis, which is essential in improvement demand analysis, in step 5 of the total solution.

Table 7. Functions of Risk Analysis Program by Part

Part	Function
Risk	Calculate the cost of risk by aggregating variables necessary in risk analysis and the previously established inventory DB
Remaining Service Life Prediction	Display graphs on frequency of damages by pipe diameter/ grade in relation to the calculated cost of risk and the amount of damage caused by leakage and detections

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