Status of Asset Management in Germany

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IN THE ASSET MANAGEMENT of wastewater infrastructure systems, a paradigm shift has occurred in the Federal Republic of Germany over the last 17 years. The starting point was the realization that essential technical and commercial data used as a basis for asset management are insufficient. These quality deficits primarily concern defect and condition classes in the area of technical data and book and residual book values in the area of commercial data.

The problem with the defect classes of sewers and pipes is that they are recorded over a long period of time with the help of CCTV inspections. Fifteen or more years can pass before a drain and sewer system is fully inspected. The same applies to repeat inspections, although in Germany the time limit for such inspections is 10 years. With such long periods of time, the normative assessment and classification systems of defects can change, so that, as a rule, there are no homogeneous and thus comparable assessments in the database. Regardless of this, only a small amount of defect and condition data represents the current situation (see Figure 5). In addition, the condition class is defined by the most severe single defect detected in a sewer section. This may be sufficient to derive a rehabilitation priority, but not to derive a rehabilitation decision regarding the need for repair, renovation or replacement of the sewer section [STEIN04a], [STEIN04b], [STEIN05a]. It is also critical that an "imprecise", unprofessional or non-compliant defect assessment by the inspector can lead to one or more class changes in the condition class. The condition class is therefore not a very resilient criterion.

Book or residual book values are also of limited use as management information for optimizing investment decisions. The depreciation period on which the book values are based is often an estimated, political value. Ideally, the depreciation period represents the actual mean value of the technical useful life of asset elements within the network. This means that even in the ideal case, many network objects are not usable for such a long time that depreciation losses will occur and, on the other hand, are usable for a longer time without being able to generate revenue in the form of fees [STEIN09a], [Stacho19]. Thus, key figures like the Remaining Useful Life (RUL) are just a subjective estimation and a realistic derivation of object specific (Remaining) Useful Life is therefore not possible.

To compensate for the deficits of condition class and residual book values described above, STEIN [STEIN14a], [STEIN13a], [STEIN16a] developed the object-specific key figures substance class and substance value as supplementary management information in 2003, which revolutionizes the quality and scope of data-based asset management by including aging models. The process as well as the results that are possible with this information in the context of an extended Urban Infrastructure Life Cycle Management process are explained using the example of the asset management system STATUS.

Fabric deterioration class as basis for the d the substance value

An extended evaluation concept has been integrated into STATUS, which divides the evaluation of a sewer system into a condition class and a fabric deterioration class, as explained in Figure 1.

The condition class of a sewer section (Table 1) as an indicator for the actual function fulfillment (priority) is determined analogously to the standard evaluation models also in STATUS by the most severe single defect within the considered sewer section. However, the difference is that the discrete condition classes are not used, since the defect assessment is already carried out in a stepless manner, taking structural boundary conditions into account. This allows a realistic evaluation of the individual defects without loss of information due to classification in a discrete defect and condition class. To further increase the quality of information and analysis, the defects are classified according to their impact on the environment (leak tightness), stability and operation. This differentiation avoids that e.g. defect assessment, like deposits, influence the stability evaluation of a sewer section. Management decisions from a structural, operational or environmental point of view can thus be derived cleanly and separately from each other.

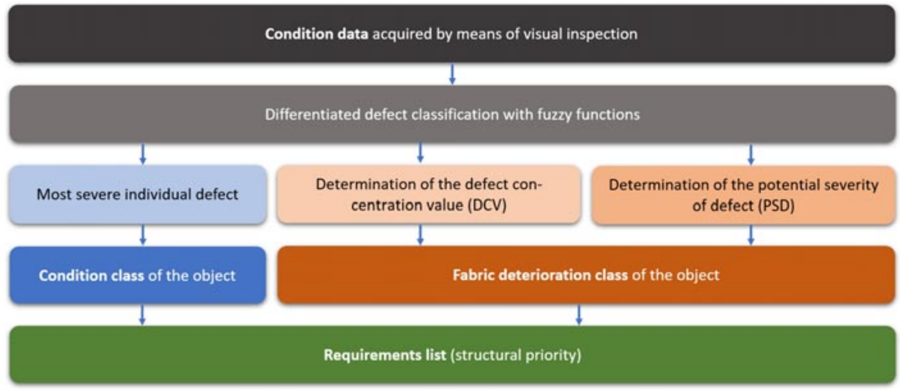


Figure 1: Workflow of "object assessment" based on the Fabric deterioration classification

The fabric deterioration (Table 2) represents the overall condition of a sewer section, considering all defects in the section, and thus characterizes the remaining wear reserve until the occurrence of the mandatory replacement. A rehabilitation action with a correspondingly high wear reserve - even before it is completely consumed - enables the use of more cost-effective rehabilitation solutions (renovation or repair). Thus, with the exact knowledge of the fabric deterioration of a sewer section, foresighted and cost-optimized planning on a secured data basis is possible. The fabric deterioration assessment takes into account all the defects listed and assessed in the sewer section with their respective individual defect class as well as their spatial distribution or concentration and their individual defect length. The consid-

(Individual) Defect class		**Section related Condition class** (Rehabilitation priority)	
Differentiated into protection goals: environment / tightness, operational safety, structural stability	DC 5 No defect DC 4 Minor defect DC 3 Slight defect DC 2 Medium defect DC 1 Severe deficiency DC 0 Very severe defect	Differentiated into protection goals: environment / tightness, operational safety, structural stability	CC 5 No defect CC 4 Subordinate action CC 3 Long-term action CC 2 Medium-term action CC 1 Short-term action CC 0 Immediate action

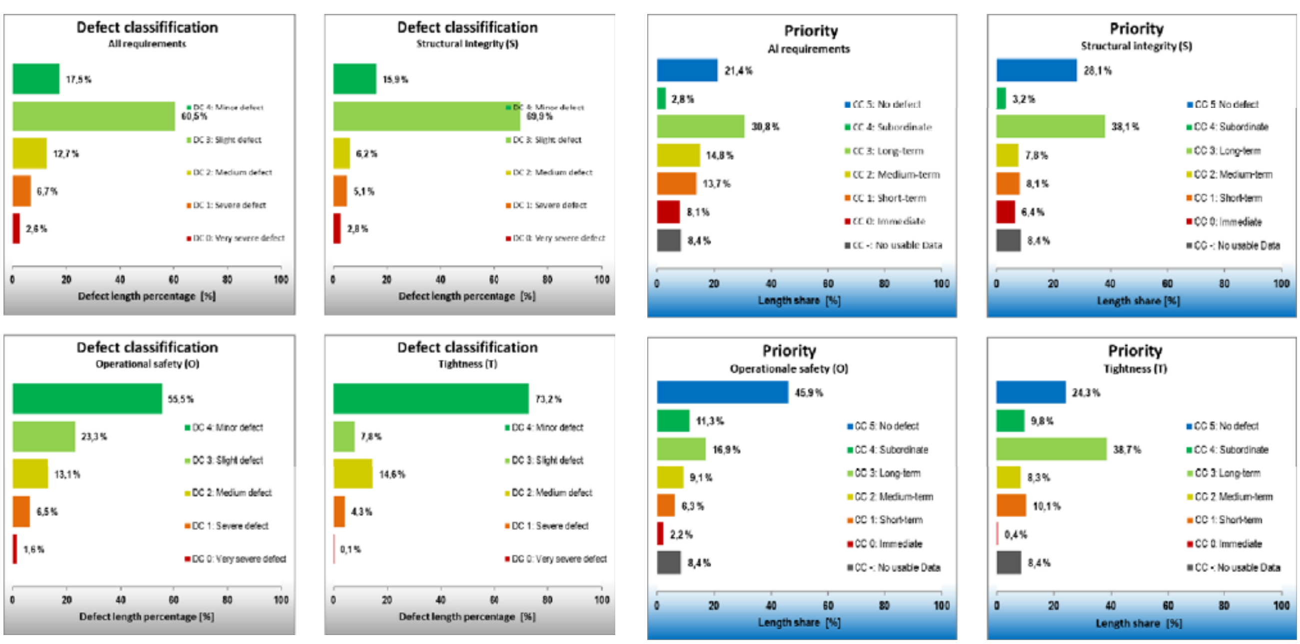


Table 1: Defect and condition classes and graphical representation by protection goals in % and [km]

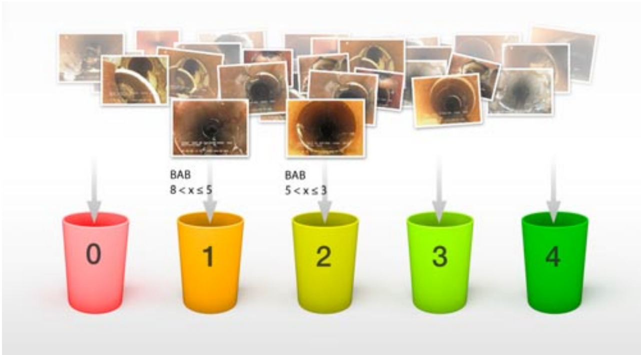


Figure 2: Principle of condition classification with rigid class boundaries [STEIN-ISM]

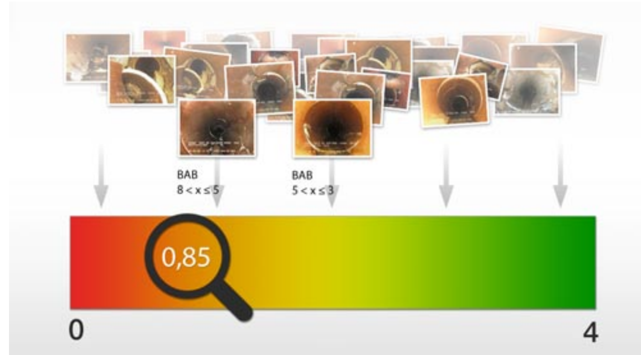


Figure 3: Principle of condition classification with no class boundaries (continuous assessment) [STEIN-ISM]

eration of all defects significantly increases the resilience of the fabric deterioration class as an important management criterion. For the analysis according to protection goals, only those defects are considered that have also been assigned a defect class in the corresponding protection goal.

Figure 4 shows the difference between condition class and fabric deterioration class.

Figure 5 shows an example of the relationship between condition class and fabric deterioration class. It is clearly visible that the critical fabric deterioration class (Wear reserve used up) at the time of inspection is much lower at 1% than the condition class at 12.2%. This shows that even sewer sections with severe individual defects can still have good fabric deterioration class. However, the figure also shows that condition data collected over longer periods of time do not allow a realistic assessment of the current structural situation. The actual rehabilitation

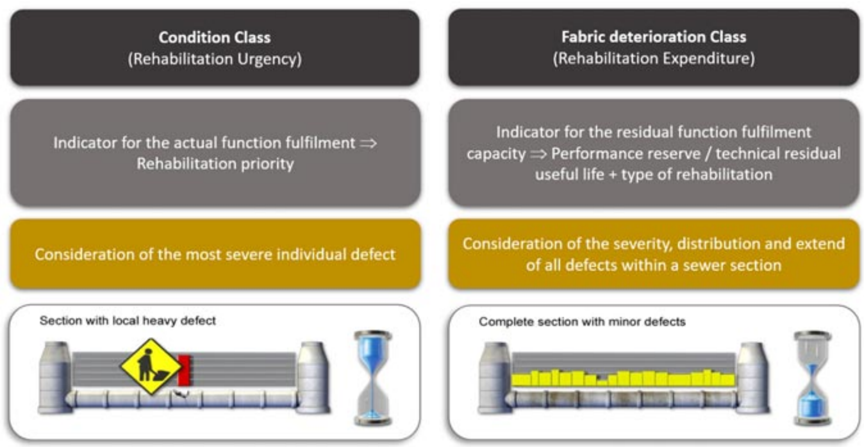


Figure 4: Comparison of condition and fabric deterioration assessment (sewer section) [STEIN14a]

Fabric deterioration class

Differentiated into protection goals: environment / tightness, operational safe ty, structural stability

Classification

FDC 5 Full wear reserve

FDC 4 Very high wear reserve

FDC 3 High wear reserve

FDC 2 Medium wear reserve

FDC 1 Low wear reserve

FDC 0 Wear reserve used up

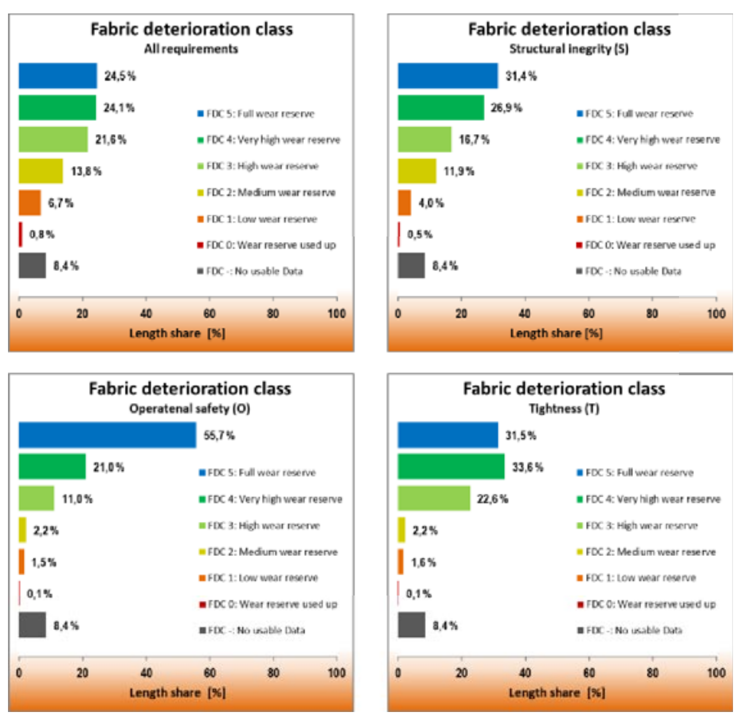


Table 2: Fabric deterioration classes and graphical representation by protection goals in % and [km]

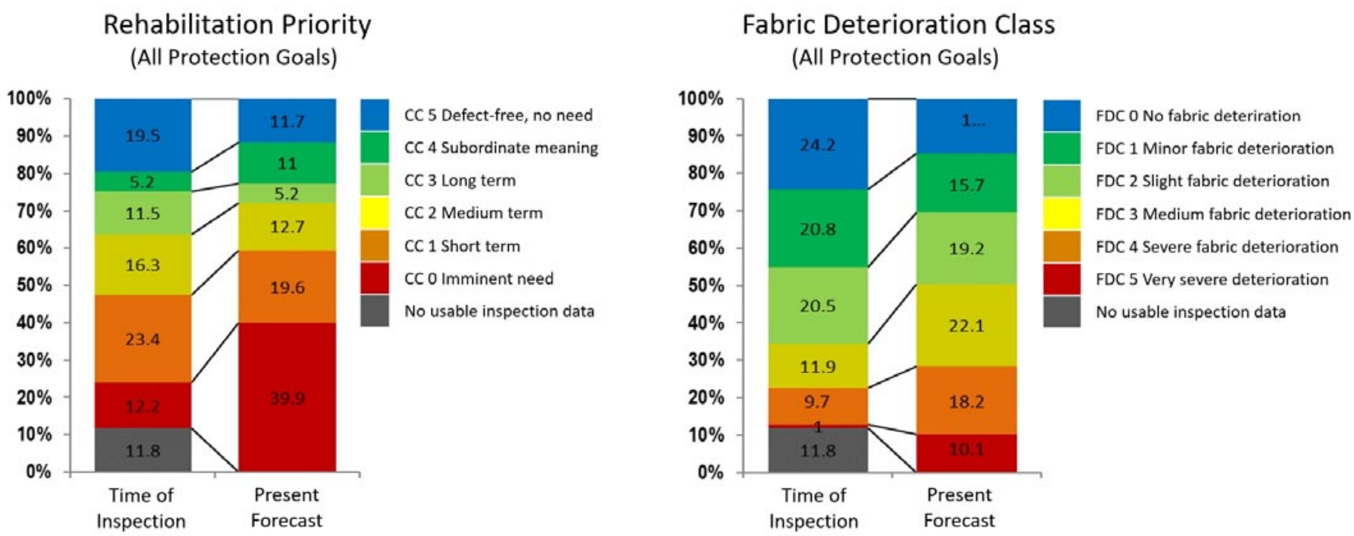


Figure 5: Database gap between historic records and the current state and comparison of condition classes (left) and fabric deterioration classes (right) at the time of inspection (left) with the current situation (present forecast) (right)

task can only be identified by a present-day forecast of the development of condition classes and fabric deterioration classes.

Remaining useful lives and net asset values

With the help of the fabric deterioration class and the replacement costs, the net asset value can also be calculated. This value represents the physical value of a sewer network or an individual sewer object, considering all existing defects. The net asset value is expressed in current prices. At the time of proper construction, the net asset value of a structure and the replacement value are identical. At the time of decommissioning of the structure for technical reasons, the net asset value is exhausted and is 0.

With the help of the STATUS aging model, the deterioration of the condition and the consumption of the wear reserve (fabric deterioration) can now be predicted. The results of this process include object-specific (residual) useful lives. This makes it possible to visualize potential depreciation losses, considering the respective depreciation periods (Figure 6).

Strategy development and optimization

Strategic planning should include optimizing the strategy selected. This includes determining the metrics for evaluating the maintenance or rehabilitation program, such as the budget, rehabilitation project duration or completing the project by a specific date. For this purpose, the process analysis of the current management approaches and their optimization is required to capture the conditions, criteria and limits of intervention decisions. It must be ensured that all background and boundary conditions influencing the client's decision on the main type of rehabilitation (repair/ renovation/ replacement) and the timing of the rehabilitation are transferred without contradiction into a transparent decision model. This means that all rehabilitation decisions made within the framework of the strategies can be traced at any time and justified on the basis of the decision model (Figure 7).

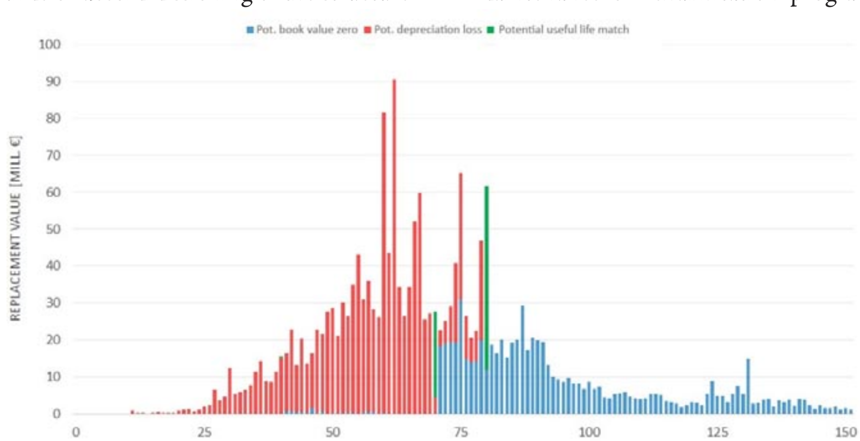


Figure 6: Significance of fabric deterioration development for the useful life related to the replacement cost (based on undisturbed ageing of the network) – the green color symbolizes sewer sections, which fit into the depreciation period of the client (70 and 80 years), red color symbolizes sewer sections, which will probably not reach the end of the planed depreciation and the blue color represents sewer sections which not contribute to the book value (book value = 0)

Deriving the most appropriate strategy is an iterative optimization process. As a rule, network operators formulate at least 3 objectives, all of which are to be achieved:

1. Reduce risks in the network by reducing the most critical defects.
2. Preservation of asset value and minimization of depreciation losses
3. Stabilization of fee income and transparent communication with administrative bodies and citizens.

The optimal path of action to achieve these objectives must consider a wide range of structural, hydraulic, operational, and environmental issues of similar priority, while respecting social, legal, economic, and environmental constraints. The result of this iterative process is the

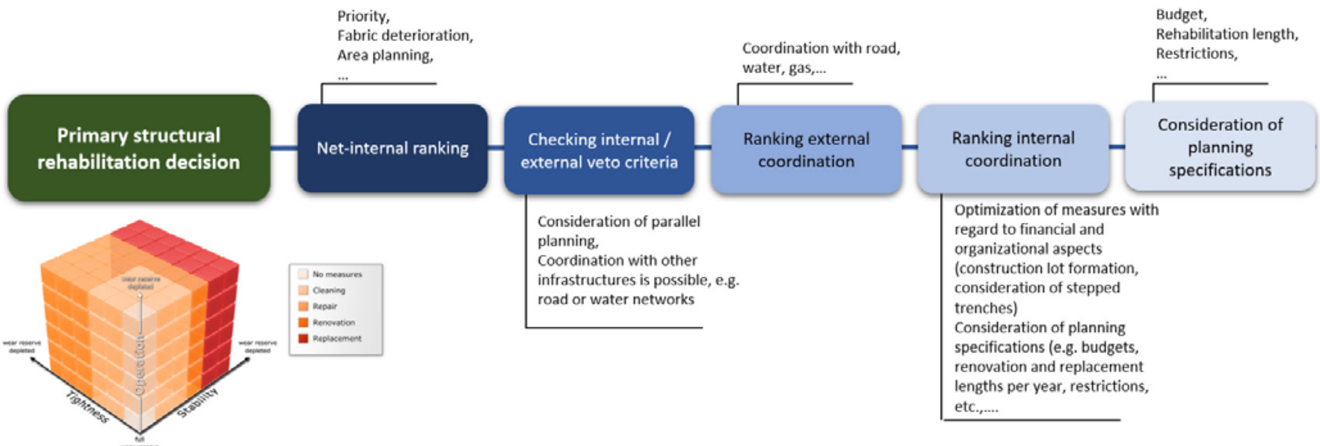


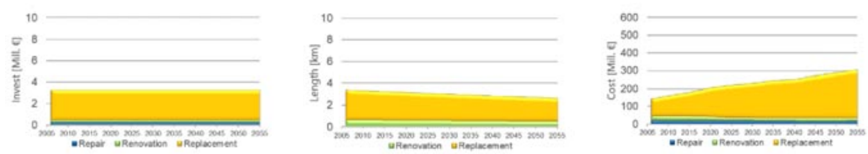
Figure 7: Example of influencing criteria on the client's decision-making process [STEIN-ISM]

"optimized strategy."

To be able to evaluate individual strategies in terms of their effectiveness and efficiency as part of the strategic optimization process, a benchmark is required. This benchmark is provided by the "carry on" strategy. This strategy variant implies that the previous rehabilitation practice of the network operator is continued for the future. Thus, it is investigated how the drain and sewer system will develop with unchanged actions and current budgets. The "carry on" strategy is the most important reference strategy, as it can be used to analyze the previous approach and examine its future stability and sustainability, and to examine the effectiveness of alternative strategies.

The following tables show the effects of the "carry on" and "optimized" strategies in terms of investments, rehabilitation length, rehabilitation backlog, condition and fabric deterioration development.

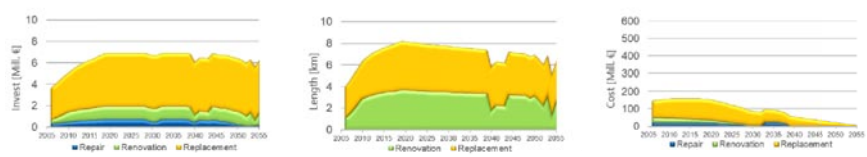
Table 4 compares the cumulative financial / asset values over a period of 30 years for the "carry on" and the "optimized" strategy. In addition, the "natural", undisturbed network aging in the form of the "zero investment" strategy is listed as a further reference system. As expected, undisturbed network aging, which does not involve any investment in the network, leads to the highest level of asset depletion, amounting to € 135 million. It is interesting to note that a continuation of the original rehabilitation practice (carry on) also leads to a loss of net asset value in the amount of € 13 million. To assess the efficiency of the optimized strategy, rehabilitation costs should be taken into account. If these are



"Carry on" strategy: investments in the network per year for repair, renovation and replacement - budget is always utilized, indication of insufficient budget

"Carry on" strategy: Lengths of rehabilitation per year for renovation and replacements

"Carry on" strategy: Rehabilitation backlog - cumulative measures per year that have not been realized based on planned costs - risks in the network increase, resilience decreases

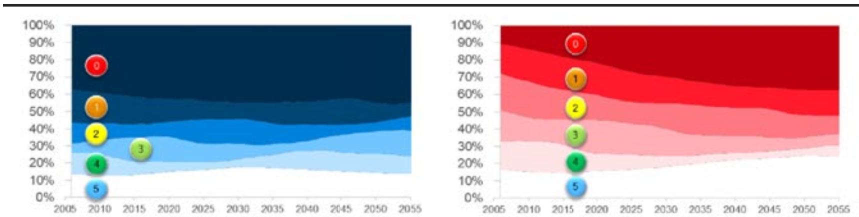


"Optimized" strategy: investment in the network per year for repair, renovation and replacement - budget increase in the first 7 years 1% and another 7 years 0.5%.

"Optimized" strategy: rehabilitation lengths per year for renovation and replacement - increase of renovation budget significantly increases annual renovation length

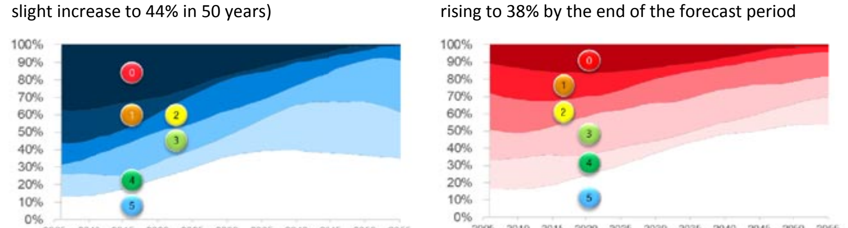
"Optimized" strategy: rehabilitation backlog - cumulative measures per year not realized based on planned costs- risks in the network decrease, resilience increases, probability of successful strategy implementation is high

Table 3: Comparison of investments, rehabilitation length and rehabilitation backlog



"Carry on" strategy: High percentage of critical defects (required Immediate action CC 0 = 37%) and slight increase to 44% in 50 years)

"Carry on" strategy: At the start time, 11% of the sewer sections with "wear reserve used up" (FDC0), rising to 38% by the end of the forecast period



"Optimized" strategy: "Reduction of risks in the network" objective is achieved in the long term

"Optimized" strategy: "Preservation of net asset value" target achieved in the medium term

Table 4: Comparison of condition and fabric deterioration development

deducted, the results are negative for all 3 strategy scenarios, but the differences are enormous. If "carry on" would lead to a negative balance of € -110.05, this is only € -45 million for the optimized strategy. The delta of 65 million thus corresponds to an adjusted value retention of € 2.3 million / year. If the income from fees is included in the form of a "net asset value balance", it becomes clear that an increase in the rehabilitation costs by 92% can lead to an increase in the net asset value balance by 360%.

		Zero-Investment	Carry-on	Optimized
1	Net Asset Value Start	255	259	259
2	Net Asset Value End	119	246	400,42
3	**Delta (2-1)**	**-136**	**-13**	**141,42**
4	Rehabilitation Costs	0	97,5	186,76
5	**Delta (3-4)**	**-136**	**-110,5**	**-45,34**
6	Income & losses from fees (total)	40,98	167,03	305,99
	Net asset value balance (total)			
7	**Delta (6-5)**	**-95,02**	**56,53**	**260,65**

Table 5: Financial comparison for a forecast period of 30 years in millions of euros for a drainage system with a length of 480 km

Summary

Network operators are trying to achieve three main objectives with their asset management approaches:

- Reduce risks in the network by reducing the most critical defects
- Preservation of asset value and minimization of depreciation losses
- Stabilization of fee income and transparent communication with administrative bodies and citizens.

These goals can only be achieved with modern asset management systems that can calculate and forecast a realistic, engineering-based assessment of the structural / fabric deterioration of an object and its asset value as well as its development over time. With this information base, network-specific, well-founded and reproducible effectiveness analyses of strategy in relation to the above-mentioned objectives are possible. This makes the long-term consequences of current strategy decisions transparent and allows strategies to be adapted to the respective targets. With the help of "STATUS", this forward-looking strategic planning is possible in a consistent and reproducible manner. The exact and resilient integrated forecast model allows a well-founded prediction of the network development, both for an "intervention-free" network aging and due to a selected strategy, by means of a realistic, mathematically exact modeling of the aging processes of sewer sections and manholes.

With this decision support, a consistent assessment of risks as well as risk development and its impact on service levels and performance targets is possible. Investments can be safely planned and effectively allocated over longer periods of time, ultimately enabling sustainable asset development and transformation while optimizing budget allocation.

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