

## Intelligent Sewer Management

How AI-based methods make inspection data strategically usable



**The new ISAM tool from IBAK contains some valuable working aids that support the condition assessment and ageing prognosis of sewers.**

Michael Figge, director of EURAWASSER Betriebsführungsgesellschaft mbH.

*Inconsistent inspection data collected over time is an impediment to the reliable assessment of the condition of municipal sewer networks. With IBAK Sewer Asset Management, ISAM for short, a toolbox on the basis of artificial intelligence (AI) that validates data, evaluates substances, predicts ageing processes and enables strategic decisions is under development at IBAK. This article demonstrates how modern data and AI processes pave the way for sustainable and economic infrastructure management.*

### 1. Inconsistent data, increasing challenges

The wastewater industry is increasingly confronted with the task of making it possible to sensibly utilize large volumes of inspection data that was collected over time. For decades, sewer networks have been inspected using various systems, standards and sewer codes – often inconsistently,

making comparison difficult. As a result, many wastewater authorities have no reliable basis for assessing the actual condition of their pipes and deducing from this how the entire network will develop.

In addition to this, existing sewer section data is in many cases incomplete, faulty or has not been checked for plausibility. A systematic check of this data has only been possible up to now with a great deal of manual effort. At the same time, the need for authoritative, long-term prognoses is increasing: how will the network develop? Where will the condition deteriorate most? Where does the greatest loss of value threaten? And how does that affect the future costs of the infrastructure?

This lack of data integration hampers both targeted maintenance strategies and needs-based inspection planning. Without reliable condition assessment and pro-

gnosis models, decisions on investments remain doubtful – an increasing problem in the face of limited budgets, rising requirements and ageing sewer networks.

### 2. The ISAM process chain – how strategic decisions evolve from inspection data

In order to meet these challenges, IBAK is developing a web-based, AI-aided toolbox: IBAK Sewer Asset Management (ISAM). The system will provide forward-looking, data-based and assisted management of sewer systems. The focus is on substance determination, replacement costs, sewer network ageing prognoses, maintenance scheduling and strategic network planning.

The use of artificial intelligence in sewer asset management requires maximum care with regard to transparency, safety and trustworthiness. This is why developments

at IBAK take place in compliance with high quality management aspects, among other things, the AI directive is adhered to. ISAM follows a clearly structured, coordinated process logic that will develop a strategically useful control instrument from the sewer inspection data. The process chain forms the common thread from the raw data set through to forward-looking network management – and illustrates how data become authoritative bases for decisions. The process chain is briefly described below.

## **2.1. Inspection data as the starting point**

At the beginning, there is the existing inspection data – often collected over decades and heterogeneous as a result. Different coding systems (generations of standards), interfaces and scanning quality are characteristic of this data fundament. ISAM adopts this data as a basis to start from.

## **2.2. Master data check**

Before evaluation is possible, ISAM analyses the recorded master data such as e.g. type of material, pipe dimension, year of construction or length of section. The system performs an automated plausibility check on this information and identifies any abnormalities, inconsistencies and gaps.

## **2.3. Proposals for data correction**

If ISAM discovers any discrepancies when checking the sewer section or inspection data, an integrated data correction system is provided. This is at present under development. The aim is to create a consistent and authoritative data stock. Thus, in future, the system will use methods of data analysis (statistical and logical), AI-aided pattern identification, automated text recognition and information from 3D models. The revision of the data stock will therefore be generated so to speak with a mouse click – without the great amount of manual effort that was hitherto necessary.

## **2.4. Substance calculation and replacement costs**

ISAM determines the substance values according to established methods, such as those used in the SUBKANS project, and calculates parallel to this the replacement costs of the individual sewer sections. So, in this way, an overall view of the technical and economic condition is generated – a double perspective that will become increasingly indispensable in sewer network management.

## **2.5. Prognoses of substance and value development**

On this basis, ISAM creates single section, street-by-street and network-wide prognoses: how will the substance of the network develop? Where does loss of value threaten? Which segment will be critical in five or ten years? These future prospects make more intensely apparent how the network will further develop under na-

tural ageing processes.

## **2.6. Forward-looking maintenance and inspection planning**

The last stage of the process chain makes the information deployable for practical use. The prognoses permit concrete proposals for maintenance and inspection planning: in future, it will be possible for measures to be prioritised, intervals to be adapted to needs and budgets to be secured in the long term. In addition, ISAM identifies potential hotspots, i.e. segments with a particular need for action.

## **3. Processing of inspection films**

The video data captured in the course of sewer inspections is a central source of information for ISAM. To make this information content available at highest quality level, a new method of 3D reconstruction of the pipe's interior has been developed and is presented for the first time in this article.

The inspection films are systematically processed using visual computing methods and AI-aided image analysis. High-resolution visual unfolded views (isometric scans) and a three-dimensional reconstruction of the pipe inner surface in the form of a surface model (mesh) are developed from the video sequences. These 3D models enable a more precise capture of geometric characteristics and supply authoritative information, among other things on the profile shape, the pipe dimension and structural features such as deformations or fractures.

A particular challenge to the creation of meaningful unfolded views is posed by the lighting of the scans which in practice is often uneven. Deviations from the idealised pipe geometry also present a difficulty. Both can lead to distortions, double images or deceptive distribution of brightness.

As opposed to normal practice, these effects can be remedied in a targeted way by the combination of 3D reconstruction and photogrammetric illumination correction (cf. Fig. 1).

Contrary to purely heuristic brightening methods, only the brightness variations caused by the scan are corrected, whereas real differences in colour due to the materials are retained.

The geometrically consistent and photogrammetrically corrected unfolded views created in this way form the basis for further use of the inspection films within ISAM.

#### 4. Key component – the data correction system

The data correction system is a central key component within the ISAM process chain. It uses the imported inspection data and also the newly gained information from the 3D-reconstructed and processed inspection films to create well-founded-proposals for missing or contradictory master data.

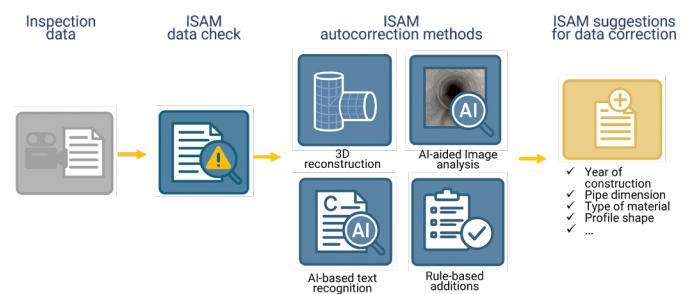


Fig 2:

ISAM autocorrection system: data check, 3D reconstruction, AI-based methods and rule-based additions for the deduction of consistent master data.

In the video material, the AI-aided image analysis identifies for example the actual pipe material. The 3D reconstruction supplies authoritative supplementary information, among other things on the profile shape and the pipe dimension. If the film contains overlaid information, an AI-based text recognition system reads this automatically and uses it to check the existing data records for plausibility.

These processes are supplemented by rule-based and stochastic methods that evaluate the technical relations and statistical patterns. On this basis, consistent supplementation proposals are developed, for instance year of construction, material, dimension or profile type.

By combining all methods, a precise and authoritative data proposal is generated. This systematically purges and supplements the data stock and makes it usable for downstream evaluation and prognosis processes in ISAM.



Experience the 3D reconstruction: Click on this link to view the stoneware support in DN 300 pipe size as a mesh in a short video animation.  
[Click here or scan the QR code.](#)



Fig 1:

Extract from an unfolded view with a 3D reconstruction and photogrammetric illumination correction. QR-Code: sequence of a sewer section of vitrified clay in DN 300 as a 3D reconstruction (mesh).

## 5. The ISAM prognosis model for the prediction of substance loss

### 5.1. Representative data set

ISAM's prognosis model is based on a comprehensive historical data set: there exist at least two consecutive inspections per section from a large number of municipalities all over Germany. This consecutive sequence makes it possible to follow the actual changes in the substance of individual sections. The model identifies from this the typical patterns of substance loss – depending on factors such as the year of construction, the material or the pipe dimension.

As the considered sections are distributed over the entire territory of the Federal Republic, first of all, a generalised model that reflects the usual courses of degradation of German sewer networks is produced from this. In order to ensure that this data set is in fact representative, it was compared with the results of the DWA survey of 2020. The fundamental network values show no relevant deviations, so that the data set can be considered as a reliable cross-section of German sewer infrastructures.

The basic model deduced from this is not inflexible, however. It serves simultaneously as a starting point for fine tuning. This permits municipalities to incorporate their specific general conditions – for instance particularly heavy loads or regional network structures. In this way, the prognosis quality can be improved in a targeted way and adapted to local conditions.

### 5.2. Validation of the model

To check the quality of the model, it started off with the known substance values of sections chosen randomly from all over Germany at an earlier time ( $t_1$ ). Then the model predicted their substance development at a later time ( $t_2$ ). The subsequent comparison of the prognosis and the actual substance at the time ( $t_2$ ) shows high accordance ( $R^2 = 0.89$ ).

Such a value shows that the model very

reliably reproduces the real, continual substance loss of sewer sections – and is clearly superior to classical methods. At the same time, the model offers a solid basis for incorporating regional particularities and increasing the prognosis precision on site.

### 5.3. Technical and economic consideration

The ageing processes are available to users not only as a technical value (degree of wear) but also as an economic indication as a loss of value (in €). From the latter, it is evident which financial loss a sewer section suffers in the course of time due to substance loss if no conservation measures are implemented. This translates the substance loss into a concrete monetary value. This approach also makes clear which economic consequences deferred repairs have and in which areas strategic action is particularly urgent. The combination of technical substance prognosis and monetary value thus enables precise prioritisation of measures and supports forward-looking network management that keeps both the technical and economic risks in view.

## 6. Use for strategy, planning and network management

For users, ISAM opens new scope for action in the field of strategic rehabilitation and maintenance planning. For example, long-term-oriented, sustainable conservation strategies can be developed thanks to the reliable prognoses. At the same time, there is greater planning precision with reference to priorities, intervention times and the identification of critical sections in the network. Hotspots can be identified at an early stage so that efficient, targeted action can be taken.

A fundamental advantage lies in the possibility of forward-looking budget and resource planning. Instead of acting reactively like with a firefighter strategy, existing means can be used strategically and in an effect-oriented way.

Frank Werner Grauvogel, departmental

head, wastewater authority, planning and construction, deputy division management, Technische Betriebe Solingen explains 'Besides climate change and the shortage of skilled personnel, digitisation is one of the great challenges facing municipal sewage departments. Wastewater authorities have always had extensive network data and also tools for evaluation and control at their disposal. Besides classical defects assessment, the wastewater industry is focusing more and more on the substance of sewer networks, particularly against the background of considerable future investments which have long become a concern, not only on the wastewater sector. With the considerable wealth of data gathered over many decades of documentation with IBAK hardware and software from the self-monitoring ordinances, the Technische Betriebe Solingen have an extensive basis at their disposal. The ISAM project enhances this potential and provides the Technische Betriebe with authoritative results for secure investment planning, taking into account the condition and substance of the sewer network.'

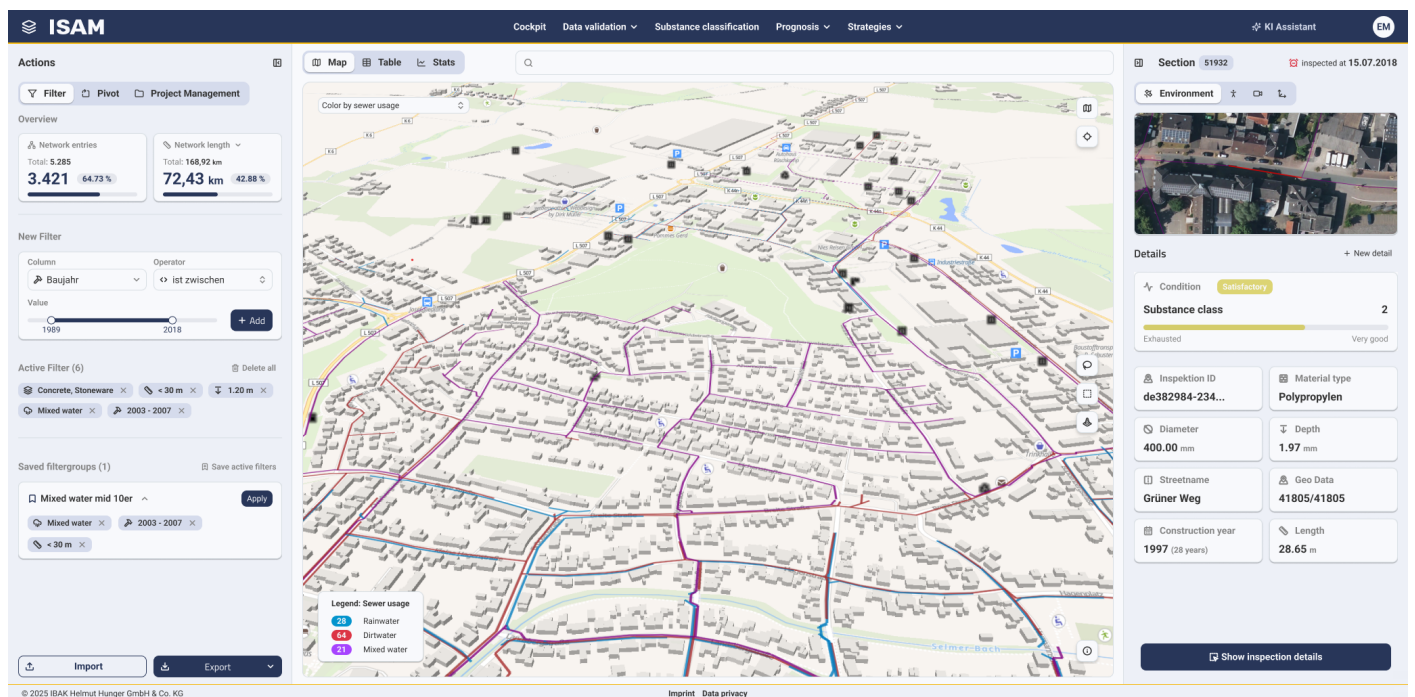
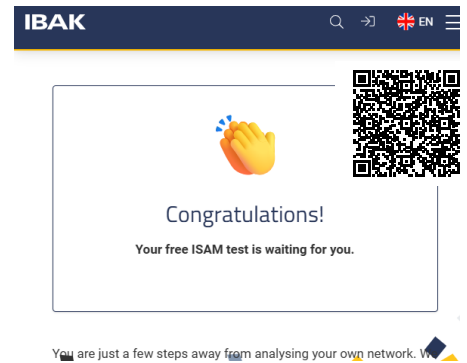
Users can perform analyses at various aggregation levels – from a single section through entire streets to the complete sewer network. Substance classifications, prioritising schemes and scenario analyses will be available in a structured way and support data-based decisions at all levels of network management. In order to make the described analysis methods available area-wide, IBAK will provide the Sewer Asset Management (ISAM) as an efficient web service. Access via a modern cloud infrastructure will make it possible for municipalities, wastewater authorities and engineering offices to utilize the AI-based evaluation and prognosis instruments without having to use their own computing resources or complex software installations.

'The new ISAM tool from IBAK contains some valuable working aids that support the condition assessment and ageing prognosis of sewers. Beginning with the integrated checking of the existing data for plau-

sibility via the geographical presentation of condition and substance classes at section and network level through to the monetary evaluation of the rehabilitation work, this is all performed on a uniform platform. The whole thing is reproducible and transparent. With the ISAM tool, in particular wastewater authorities with smaller sewer systems can in this way rapidly, intuitively and easily obtain a first overview of their wastewater system which previously required a great deal of manual effort. EURAWASSER has intensively accompanied the development of the ISAM tool and is looking forward to when it will in future be available to our organisations in our daily work,' states Michael Figge, director of EURAWASSER

Betriebsführungsgesellschaft mbH.

**Test ISAM** – with your own subnetwork: Click on [this link](#) or scan the QR code to get to know the functionality of ISAM (no obligations).



**Fig 3:** With ISAM, IBAK is developing a toolbox on the basis of artificial intelligence (AI) that validates data, evaluates substances, predicts ageing processes and enables strategic decisions.