# Data-driven Approaches to Pipeline Cleaning

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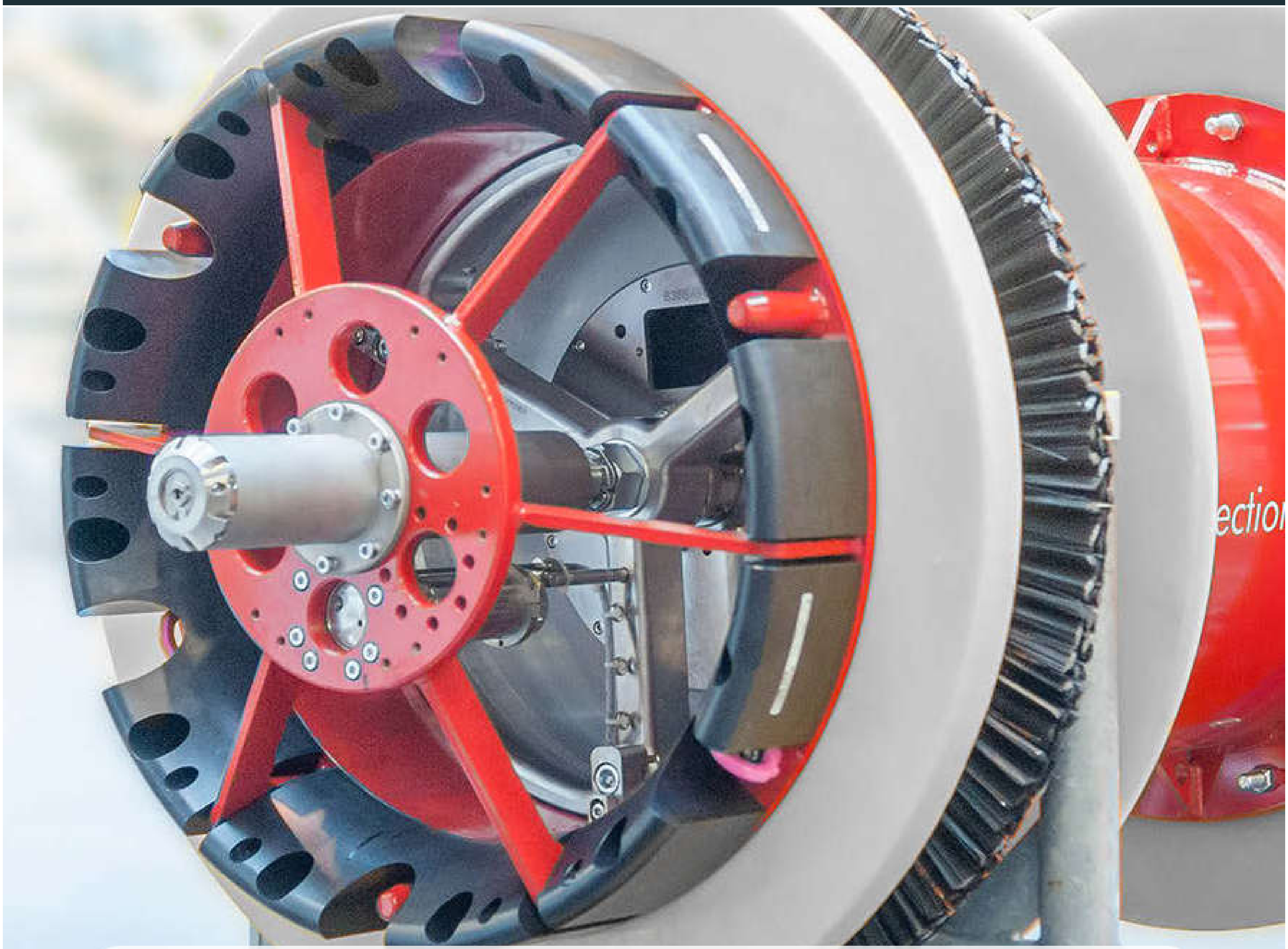


## Abstract

Data-driven approaches are gaining momentum in the pipeline industry. Proactive pipeline maintenance requires the collection and management of data from cleaning programs for future use. This paper illustrates an approach which allows pipeline operators the opportunity to build up a database of information on their assets from standard cleaning runs. Intelligent Gauge Plates and Pipeline Data Loggers (PDLs) can also be integrated in the tool's setup for more comprehensive analysis. A wide range of analytics can be brought to bear upon these databases. The resulting knowledge of the pipeline conditions offers a greater degree of confidence that a line is ready for further in-line inspection, ultimately increasing first-run success rates while reducing risk.

## THE NEED FOR PIPELINE CLEANING

The efficient operation of a pipeline is dependent upon maintenance of the internal diameter to ensure optimal flow of the medium. There are a range of significant processes at work inside a pipeline working to decrease flow efficiency. Primarily, ongoing accumulation of deposits which can either cause damage through abrasion or encourage corrosion as a result of the deposits. Compromised pipeline surfaces prohibit corrosion inhibitors from being applied consistently. Product contamination can result, and system contamination can complicate the preparatory work necessary to ensure high quality data from an inline inspection (ILI).

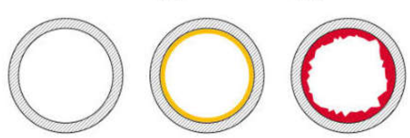
The absence of a cleaning regime can dramatically affect the efficiency, safety, and reliability of the entire network. Foreign matter and buildup can damage the integrity of a pipeline, encourage the formation of corrosion and pipe thinning, and will almost certainly reduce throughput.

As can be seen in Figure 1 below, even smooth deposits can result in a loss of throughput, anywhere between 10-35% in the case of uneven deposits.

Effective cleaning programs are about optimization of the maintenance budget to reduce inefficiencies, maximizing pipeline uptime and product throughput, and extending the lifespan of the asset.

A wide range of cleaning tool technologies exist, including unidirectional and bi-directional tools ranging from light to heavy duty, and equipped with brushes, sealing and scraper discs and magnets to suit.

It is even possible to include speed control options in the newest generation of tools (see Figure 2).



| | NO DEPOSIT | SMOOTH DEPOSIT 5% | UNEVEN DEPOSIT 5% |
|---|---|---|---|
| LOSS OF TROUGHPUT | Nil | c. 10% | c. 35% |
| REQUIRED INCREASE OF PRESSURE TO MAINTAIN CONSTANT FLOW | Nil | c. 30% | c. 140% |

Figure 1: Loss of throughput in the case of pipeline deposits

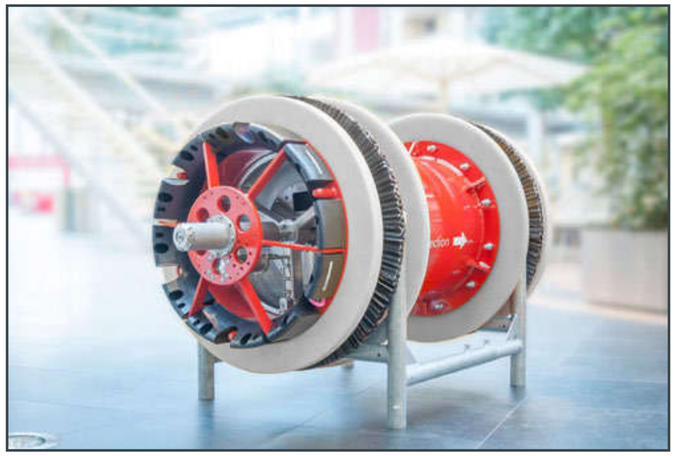


Figure 2: Speed control to optimize cleaning tool operation

## THE EMERGENCE OF DATA-DRIVEN APPROACHES

Recent years have seen the emergence of data-driven approaches in a wide range of industries. The pipeline industry is no exception.

This phenomenon can be attributed to the increasing popularity of approaches such as Risk-Based Inspection and Risk-Based Maintenance Management Frameworks. Data-driven approaches are methods originally developed in the computational sciences in which decisions made are based on the collection and analysis of data rather than pre-conceived ideas or existing knowledge about what is happening in the system.

All too often, no data is captured on cleaning run conditions with regards to type, volume, or nature of the debris removed during the process. This means that operators may be missing tangible information regarding pipeline conditions that could provide guidance on whether an in-line inspection can be conducted smoothly, or if the cleaning program is effective.

This may result in uncertainties and increased risks for the efficient transportation of products and operational cleaning or inspection tool runs.

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Figure 3: Ruggedized field tablet with custom form for data collection

> *"The systematic collection, organization and management of cleaning data will facilitate a wide range of analytical approaches.*
>
> Otto Huisman

## Pipeline data collection

The concept behind data-driven cleaning is quite simple: collect as much data as possible during launch, cleaning run and receipt of the cleaning pig, and use this information to accurately determine the internal pipeline condition, as well as possible improvements to the tool configuration, tool speed inside the line, inspection interval, etcetera.

Implementing such approaches successfully requires the collection of significant amounts of data to drive a robust set of analytics, which in turn provide inputs into planning and maintenance processes. In the pipeline arena, significant complexity is introduced due to the need to combine various design and operational variables, including pipeline diameter, pressure, etcetera.

ROSEN's new Cleaning Analytic Service was developed specifically to address these issues and provides pipeline operators with the opportunity to build up a database of information on their assets from standard cleaning runs. The service captures information from multiple sources at the beginning and end of each cleaning run.

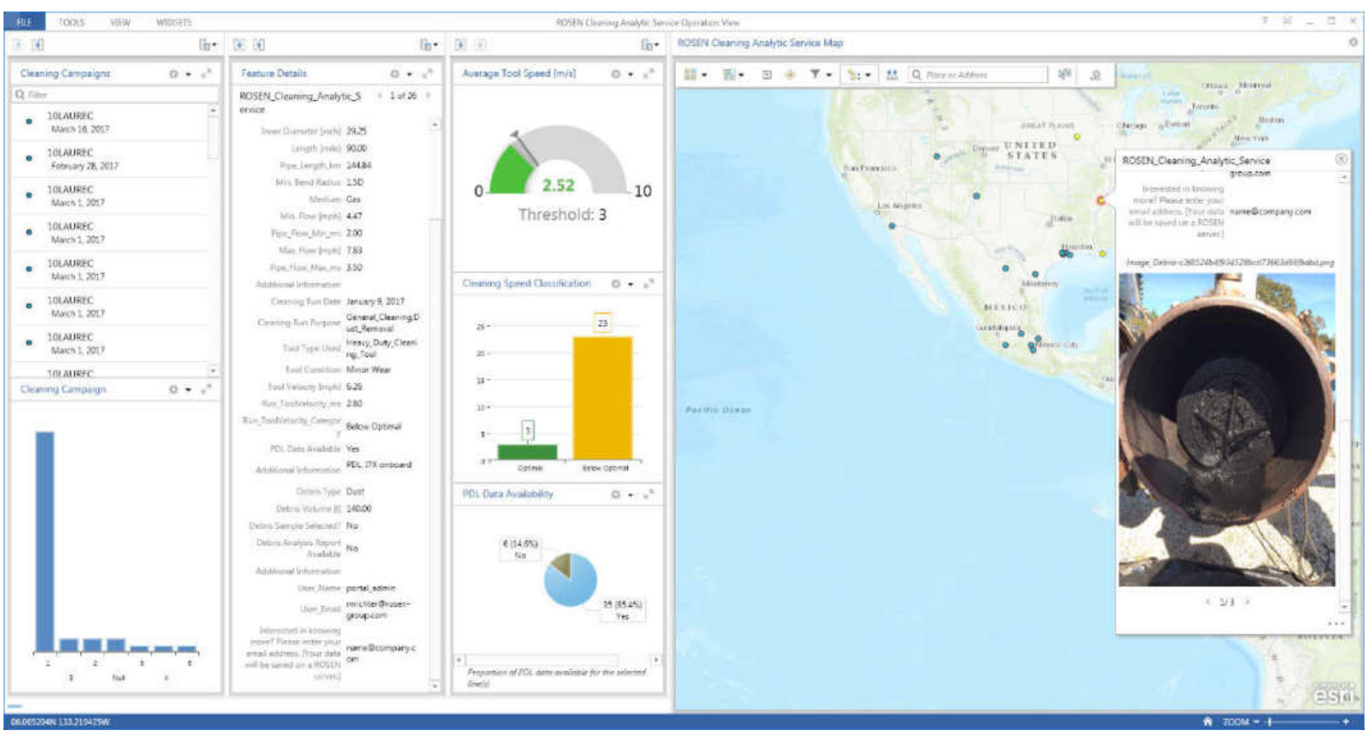


Figure 4: KPI Dashboard presenting summary data and statistics

The Service consists of three main components:

1. Smart Monitoring. Data such as trap conditions, received tool conditions, debris type and volume, and photographic evidence is captured and uploaded in-field using ruggedized (and if necessary, ATEX certified) hardware such as tablets (Figure 3). Operational cleaning data can also be collected by incorporating intelligent units such as ROSEN Pipeline Data Loggers (PDL) and Intelligent Gauge Plates into standard cleaning tools. Pipeline Data Loggers collect and store operational data during a pipeline inspection. They provide operators with detailed time dependent data such as temperature of the medium, pressure conditions in the pipeline, including differential pressure and acceleration, even indication of bends including bend angle. The latest PDLs can be attached to any standard cleaning tool and can record for more than 30 days and up to 500 km (310 miles) of inspection. Intelligent gauge plates are a newer technology, developed to assess the internal geometry of the pipeline, able to detect internal deformations which may restrict flow or prevent the passage of an ILI tool.

2. Data Management refers to the transfer of the captured data to a secure ROSEN cloud. Often, Wi-Fi or cellular data connections are available directly in the field. If these are not available, upload can take place as soon as a data connection can be established. From the in-field device, data captured in the form is transferred to a hosted database for analysis and monitoring of the cleaning program. A web dashboard is a key part of the service. This provides a constantly updated view of cleaning operations data (Figure 4) which has been uploaded. KPIs can be configured in the dashboard to summarize specific data which is collected in the field, providing potentially valuable insights to inform decision making, and if necessary, trigger more detailed investigations into problematic pipeline locations. Once the data is uploaded It is also possible to draw upon the wealth of other internal databases to better inform the analyses and potential recommendations using a range of data mining and machine learning approaches.

3. Assessment includes the analysis of existing data and detailed reporting. The collective assessment of Operational parameters and monitoring of tool behavior during the run can be utilized to detect and locate restrictions or deposits in the line and provide information on cleaning progress and effectiveness, while verifying operational pipeline conditions. When applied to consecutive runs, such an approach enables the systematic build-up of knowledge about a pipeline's development over time. A wide range of analytics can be brought to bear upon these databases, including trending of tool disc wear over time, analyses of differential pressure patterns, and ultimately, determination of the optimal way forward with regard to cleaning tool configuration, cleaning interval, and optionally, flow-assurance modelling. It is important to note here that expert knowledge still remains a critical component in the equation, specifically in the area of interpretation of results.

> *"The resulting knowledge of the pipeline conditions offers a greater degree of confidence that a line is ready for further in-line inspection, ultimately increasing first-run success rates while reducing risk*
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Figure 5:
Cleaning tool PDL data analysis showing significant pipeline deformation led to a stuck tool. Buildup of pressure eventually dislodged the tool enabling run completion

## OUTCOMES

The systematic collection, organization and management of cleaning data will facilitate a wide range of analytical approaches. Photographic evidence, while difficult to employ within an automatic processing chain, can be extremely useful as reference material. The condition of the cups and the disks on the tool and the amount and type of debris that is received can tell much about a pipeline's current operational status.

By analyzing the data from these units, it is possible to verify general pipeline conditions. Specifically, detection and location of restrictions and deposits in the line can be detected by monitoring tool behavior and differential pressure through various data integration and analytical steps (Figure 5).

Outcomes of analyses might range from recommendations for improving cleaning tool configuration to the identification and assessment of specific problem areas inside the pipeline from detailed PDL analysis. Proactive flow-assurance modelling could be employed for specific cases.

Data-driven approaches to pipeline cleaning are a quantitative approach to pipeline maintenance. The implementation of such approaches requires collection and management of data from cleaning programs for future use. We are currently witnessing a significant move towards automated evaluation of pipeline related data.

Analysis and expert interpretation of this data will ultimately benefit any additional process by offering more information from the beginning, and potentially decreasing the workload of in-line inspections.

In a system that can operate in near real-time, status alerts can be provided to give operators critical feedback such as when there is a tool in the line, when a cleaning run was successfully completed, or when a specific problem has occurred. The on-device forms can be configured to collect the required information for such notifications. The resulting knowledge of the pipeline conditions offers a greater degree of confidence that a line is ready for further in-line inspection, ultimately increasing first-run success rates while reducing risk.

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