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Visions for a Safer Future

Prof. Dr. Jürgen Schmidt
CSE Center of Safety Excellence

What is your vision for the future? Does our world have to become even safer? Surely! There are an unbelievable number of opportunities to make our plants even safer. However, we have to redefine safety and dare to cut off old "braids". Safety technology must become intelligent and adaptable to processes, and we must stop discharging hazardous substances into the environment. Actual hazards shall be evaluated just in time and initiate appropriate counter-measures dynamically. Our vision at the CSE Center of Safety Excellence is: Economic Safe-ty - higher profitability of plants without incidents and without emissions. In fact, none at all!

But how can pipelines be effectively protected? New gas compositions with additives like bio-gas and hydrogen may alter them internally. And in the future, climate-related changes such as storms with violent lightning strikes, local heavy rains etc. can cause major external dam-ages. "Keep distance" is key to protect human and environment. And in densely populated areas risk-based safety analyzes and periodical risk monitoring shall be done. This applies to corona measures as well as to long-distance gas pipelines. Here, Germany and view other countries certainly need to enhance safety.

And what about aging of pipeline networks? This question cannot be evaluated with statistical methods, looking into the past. Only research and regular inspection will help here. But do we really need research and development at all? Almost no severe incidents happen. This is an argument made by managers of yesterday. They did not understand the task. Safety is not a condition! Safety is a process that has to be achieved dynamically every day by experienced specialists. It's about trust. The trust of the public that hazards of technical systems are rea-sonably excluded. Such trust can wane very quickly. This is shown by many events up to the present day.

Safety technology has developed into an exciting subject and an interesting field of research in recent years. Gas network operator are called upon to actively contribute to this development.

Yours,

Prof. Dr. Jürgen Schmidt

CSE Center of Safety Excellence

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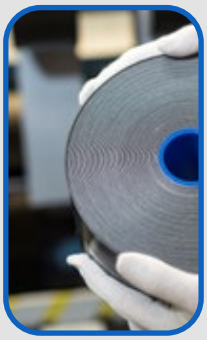
NOVEMBER 2021



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NO DIG BERLIN FOUND A NEW PLATFORM WITH THE PIPELINE TECHNOLOGY CONFERENCE (PTC) 2022

The NO DIG Berlin will be held March 8-9, 2022, at the ESTREL Congress Center, Berlin within the Pipeline Technology Conference (ptc).

The international summit was originally part of the BERLIN WASSER INTERNATIONAL (BWI) which no longer exists.

With the ptc, the European flagship event for the pipeline industry, held March 7-10, 2022, the NO DIG Berlin found a new event to partner up with, as transmission and distribution system operators and technology providers from around the world will again come to Berlin to learn about the latest developments and offerings in the industry and to exchange ideas with other operators and market participants.

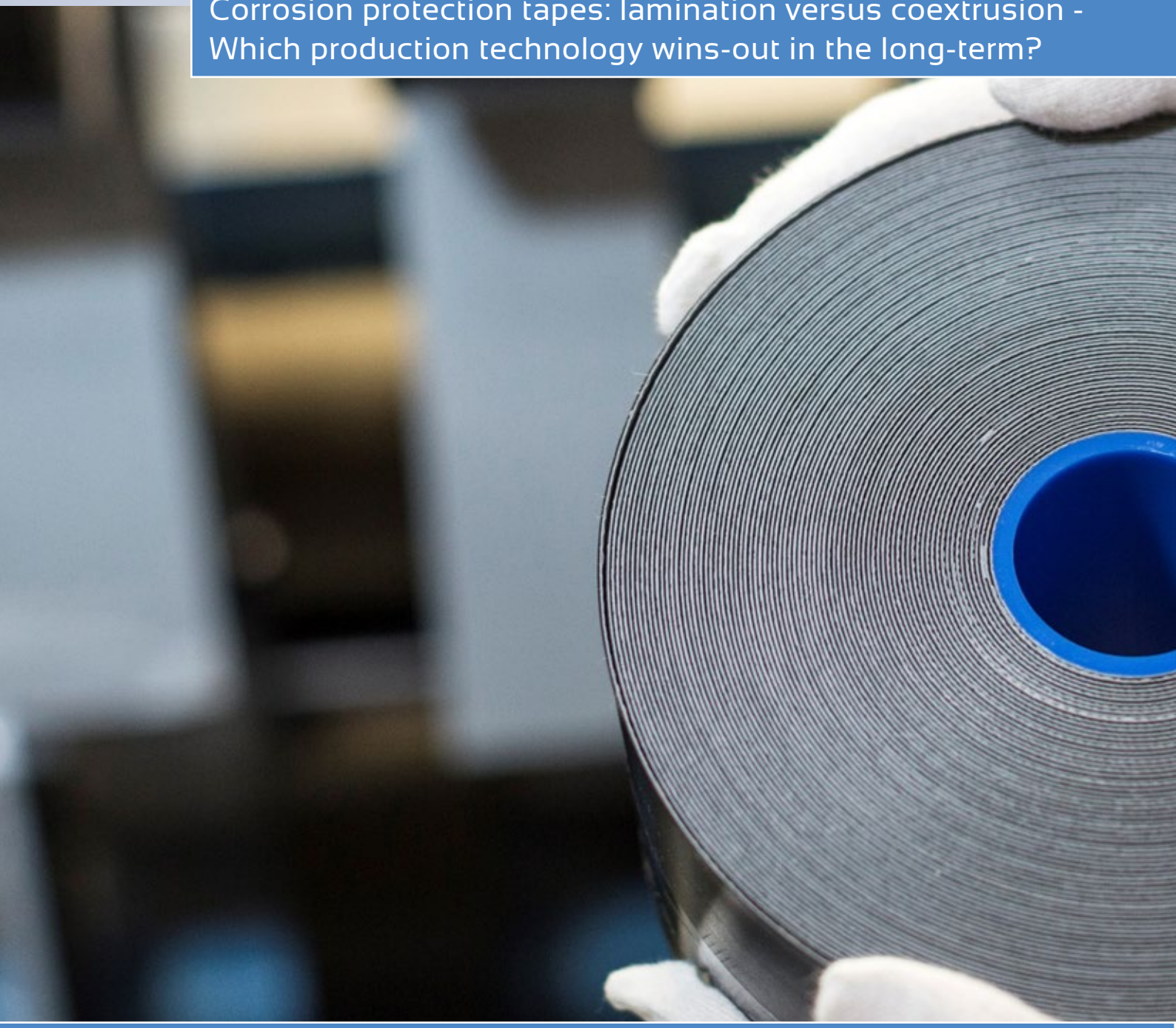
After two years in which the Pipeline Technology Conference was held exclusively online, due to the pandamic, the upcoming ptc will be a hybrid event. The central face-to-face event, ptc Berlin, will be combined with a virtual platform, ptc Remote, where all information related to the event will be available and which will offer extensive networking opportunities for all participants.

"Once again, the direct exchange in the exhibition will be a special highlight, on which we have placed a lot of emphasis in the past years and which we intend to further expand. I am excited that in addition to the technology leaders of the international pipeline industry, the upcoming ptc will also feature an increased number of participants and exhibitors from the field of municipal distribution networks thanks to a partnership with the German Society for Trenchless Technology," emphasizes Marian Ritter, Director Exhibitions of the organizer EITEP Institute. "GSTT will host its well-known trade event NO DIG Berlin for the first time within ptc 2022. We are delighted that GSTT has chosen ptc as its new venue."

Companies interested in presenting can submit proposals through the Pipeline Technology Conference online portal until Dec. 31, 2021.

During the get-togethers in the accompanying exhibition, the GSTT AWARD for innovative projects (products or construction services in Germany and/or abroad) will be awarded again on March 8, 2022. Interested companies can apply with a project to the GSTT office until January 15, 2022 (beyer@gstt.de).

Corrosion protection tapes: lamination versus coextrusion - Which production technology wins-out in the long-term?



Thomas Kaiser > DENSO Group Germany

Abstract

Steel pipelines are capital-intensive, so their service life is critical. DENSO Group Germany impressively demonstrates the vital role that superior production technology plays in the operating life of a pipeline with the exceptionally long life of its three-ply corrosion protection tapes: even after 40 years in the field, the coating with a coextruded tape system still far exceeds the current corrosion protection requirements.

But why do some tapes protect the pipe better than others over long periods? What influence does the production technology have on the material properties and how does this change the quality of corrosion protection tapes? The following comparison of the lamination and coextrusion manufacturing procedures provides the answers.

1. INTRODUCTION

To prevent a corrosive medium from gaining access to the steel surface, steel pipelines are protected against corrosion by a coating. Special corrosion protection tapes are used for the construction of new and rehabilitation of existing pipelines. These tapes consist of at least two layers, while high-quality tapes even have three different layers, which satisfy the required properties and functions.

In a three-ply tape, the middle layer gives the tape high mechanical strength and durability; it is called the carrier layer. The inner layer in contact with the pipe establishes a secure connection to the pipe surface and is called the corrosion protection layer. The outside layer, combined with the corrosion protection layer, ensures the interlinking of the spiral-wound tapes (link layer). The wound tape creates a closed tube, as the outer layer of the bottom tape fuses with the inner layer of the overlapping tape. This is something that two-ply tapes cannot do.

But even comparisons between three-ply tapes lead to significant differences that are not apparent to the human eye: so tape is not just tape. A key distinguishing feature is the production technology, which has a significant effect on the long-term behaviour of the tape system.

The different layers of the tapes consist of different materials that are interlinked by lamination or coextrusion during the production process. The one thing that all lamination technologies have in common is that at least one layer has already cooled before it its covered by another layer: a material is applied to a cold, solidified carrier film, which adheres to the carrier material similar to gluing. The different layers create a bond but are still separate from one another.

2. COEXTRUSION: A TYPE OF WELDING

It's a different story in coextrusion: in this case, different materials are present in molten form during the joining and bonding process. In the coextrusion process, the different melt flows flow into a multi-layer die via different channels. What makes this so special is that along the flow path, the individual melt flows – and therefore the macromolecules of the molten materials – increasingly combined with each other and mix to the extent that they penetrate into each other (Figure 1).

At the end of the process you get a single material line that consists of several layers. The bond established between the materials is now so strong that the strength of the material line can be compared to welding. The carrier and coating material form an inseparable unit. As a result, the film cannot separate into its individual functional layers, as is sometimes the case with laminated tapes.

Coextrusion requires expertise and a great deal of experience: every melt flow must flow at the same speed across the entire width to ensure a constant and correct thickness distribution of the material.

A simple test can be used to determine whether you are dealing with a laminated or coextruded tape: after immersing the tapes in petrol for at least two hours, the remains of the corrosion protection layer of a laminated tape can easily be mechanically removed; the carrier film is smooth or shiny. By contrast, the remains of coextruded tape are difficult to remove, even with the aid of heavy-duty mechanical tools.

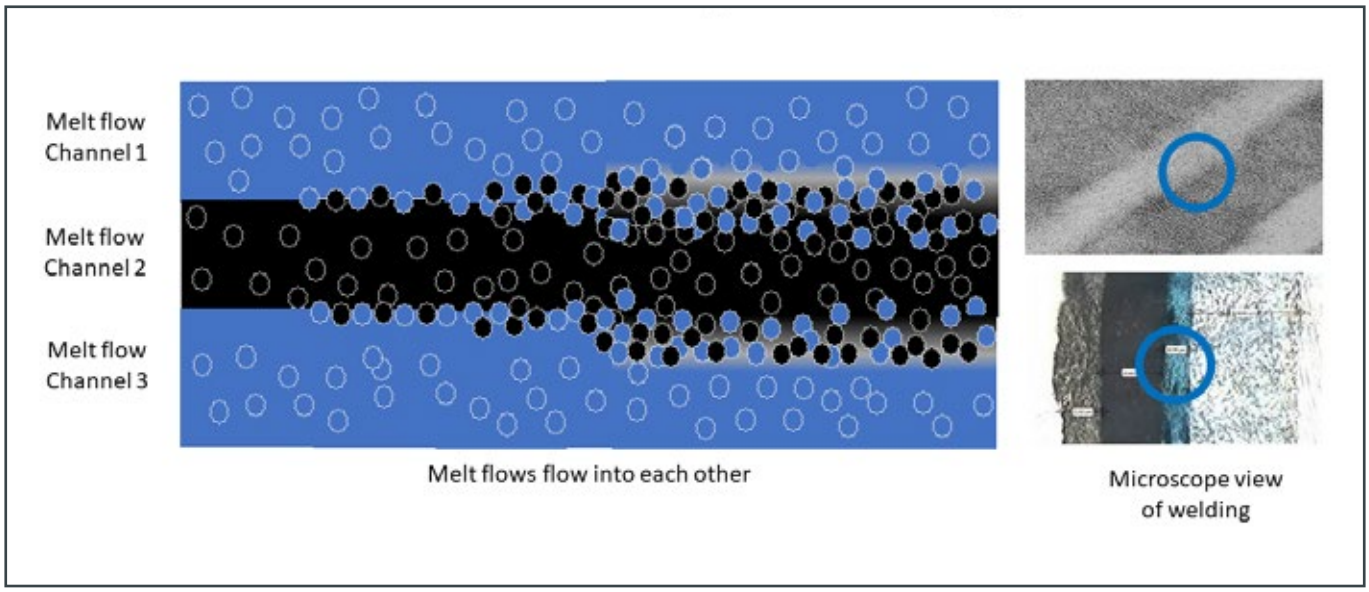


Figure 1: Coextrusion: a Type of Welding

3. BENEFITS OF COEXTRUDED TAPES: SUPERIOR LONG-TERM PROPERTIES

During installation and subsequent operation of the pipelines, the coating does not just need to withstand mechanical attacks caused by movements of the pipe and traffic loads, it also needs to offer reliable protection under extremely diverse climatic conditions. High-quality corrosion protection tapes therefore need to have excellent bonding between layers, a high lap shear strength and a high elongation at break. Taking a closer look at these material requirements shows clear differences between laminated and coextruded tapes.

In long-term use in particular, there is the risk that the carrier film will detach from the corrosion protection layer of laminated tapes, as the layers are merely "glued" to one another. The individual layers then delaminate at this kind of predetermined breaking point (adhesive separation pattern). A coextruded tape does not fail: the macromolecules flow into each other, the individual layers penetrate into each other and create a bond (Figure 2).

As a result, the bond between layers is outstanding. A coextruded tape will not detach at the interface between the carrier material and corrosion protection layer even under extreme tensile force. Instead, a fracture would occur within the layers (cohesive separation pattern). The bonding of the link layer to the carrier film could also represent a weak point, if it were not coextruded to this layer to establish a permanent bond.

4. LAP SHEAR STRENGTH AND ELONGATION AT BREAK AS SUCCESS CRITERIA

As the installed pipeline is subject to temperature fluctuations, it expands and contracts. The pipeline moves relative to the surrounding soil: this creates lap shear stress.

Coextruded tapes can withstand this stress: the individual layers do not slide over one another because the macromolecules between the individual layers are mixed and interlocked during the manufacturing process. By contrast, laminated tapes risk delamination as they only provide a "glued" bond (Figure 3). The ageing process accelerates this with a significant influence on the long-term properties. The lack of lap shear strength of laminated tapes leads to weak resistance to soil stresses – with far-reaching consequences for corrosion protection: the tapes no longer cover the entire steel surface; the protection is no longer diffusion resistant and allows corrosive media to reach the steel surface.

In addition to excellent lap shear strength, high elongation at break is another quality feature of coextruded tapes – and an indication of the use of high-quality materials and an optimal extrusion process: as opposed to lower-quality tapes, high-quality coextruded tapes can stretch much further before they tear (Figure 4).

"A direct comparison of the material properties shows that there are considerable differences in corrosion protection tapes. Coextruded tapes have a significantly higher

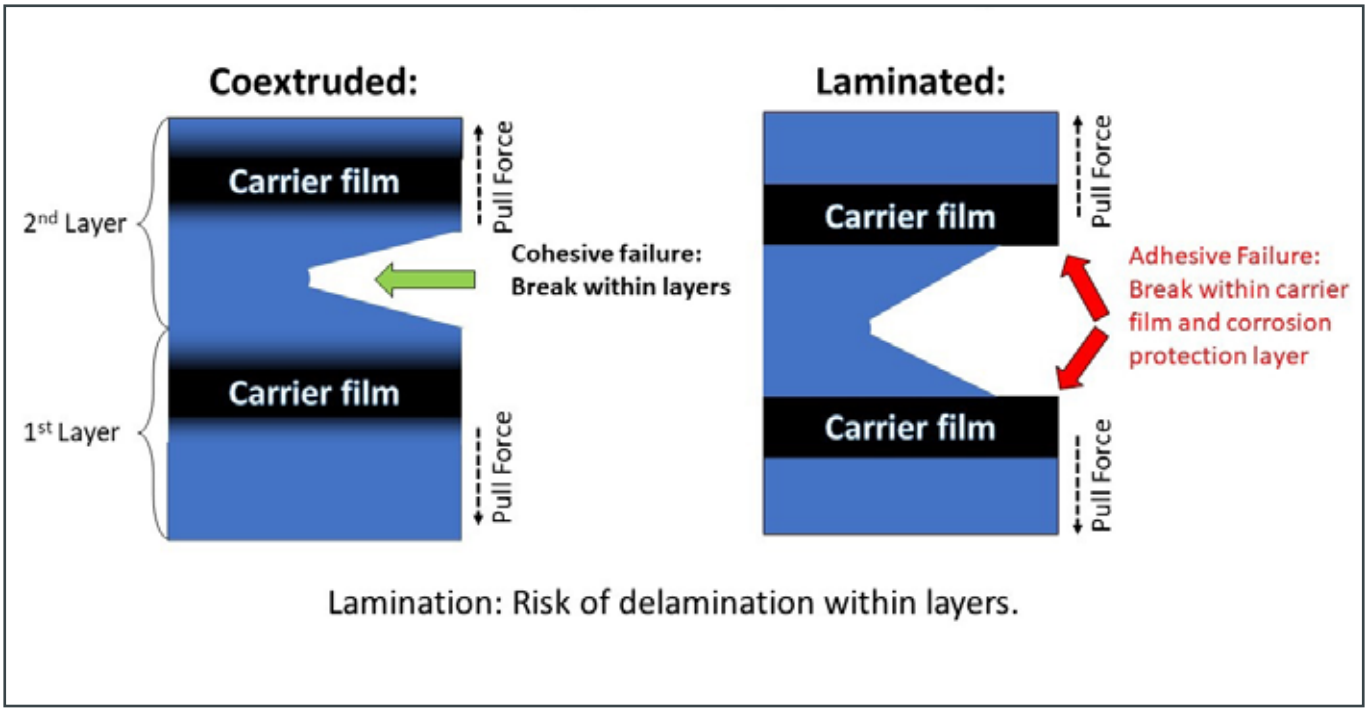


Figure 2: Coextrusion: Advantages in Layer to Layer Adhesion

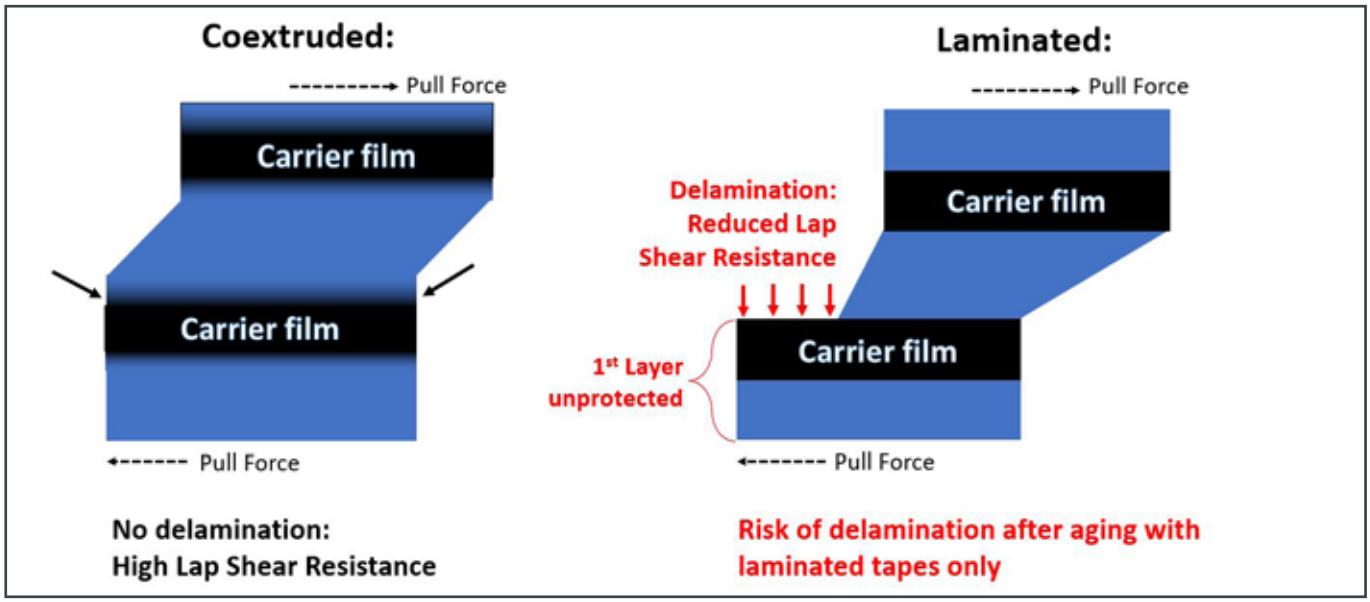


Figure 3: High Lap Shear Resistance of Coextruded Tapes

Figure 4: Faliure of laminated 2-Ply-Tapes - Poor Lap Shear Resistance: Poor Soil Stress Resistance

long-term durability and are superior to laminated tapes", explains Dr Reha Cetinkaya, Director Engineering DENSO Group Germany. "These days, pipelines have a life of at least 50 years, ideally up to 100 years. The use of high-quality tapes is essential to ensure corrosion protection over this very long timeframe."

5. PROVEN CORROSION PROTECTION AFTER FOUR DECADES

DENSO impressively showed the superior durability of coextruded tapes in practice using the tried-and-tested DENSOLEN® tape: in 2015, a modern logistics centre was built in Bavaria – precisely where the ISARSCHIENE high-pressure natural gas pipeline was installed in 1976. As part of the necessary re-routing of the gas line, the operator Energienetze Bayern GmbH excavated the 39-year-old pipes: a unique opportunity to check the durability and quality of the DENSOLEN® tapes that had been used at the time. Two coextruded three-ply tapes with a polyethylene carrier material with a butyl rubber coating on both sides had been used. A spiral-shaped winding of the three-ply tapes around the pipe allowed the butyl layers to fuse together in the overlapping areas. They formed a homogeneous, tube-like coating and were inseparably bonded to each other.

The analysis of the pipe section, which had been in continuous operation for 39 years, showed very impressive results: the pipe had no corrosion damage in the areas protected by the tape. The butyl rubber corrosion protection layer remained securely affixed to the steel, providing full protection for the pipe.

Tape Properties	Coextruded 3-ply Tapes	Laminated 3-ply Tapes
Long term performances (ageing)	High	Low
Layer-to-layer adhesion	Higher than ISO & EN	ISO & EN
Lap Shear Resistance	Higher than EN & ISO	ISO & EN
Layer-to-layer failure mode	100% Cohesive	Adhesive-Cohesive
Steel Coverage	Excellent	Limited

Table 1: Superiority of coextruded Tapes

6. LABORATORY FINDINGS: EXCEEDS THE STANDARDS

Laboratory analyses of excavated weld seam no. 584 with a pipe diameter of DN 300 were particularly revealing. Although the pipeline is located in Germany's grain-producing region, where ground vibrations are to be expected due to heavy tractors and harvesting machinery, the coating of the high-pressure pipeline showed no defects, even after four decades of use. The weld seam of the steel pipe remained protected against corrosion by the DENSOLEN® three-ply tape.

In 1976, the tape was applied with a standard specification for peel strength of 8 N/cm in accordance with DIN 30672. The current standard tests in accordance with EN 12068 and ISO 21809-3 require a higher peel strength of 10 N/cm. After 39 years, measurements showed a cohesive separation pattern with a phenomenal peel strength of 18.3 N/cm. The results of the analysis therefore exceed today's requirements by 83% (Figure 5).

Figure 5: Excellent Corrosion Protection: coextruded Tapes - Cohesive separation after 39 years in the field

7. QUALITY THAT PAYS OFF.

Even after 39 years in use, coextruded tapes still meet the current standard requirements for corrosion protection coatings. They continue to provide outstanding corrosion protection just as they have from the very first day, impressively demonstrating their long-term durability. The unique production technology has a positive impact on the material properties and performance. The outstanding bonding between layers and high lap shear strength of coextruded tapes permanently protect the pipeline. They are not susceptible to delamination or slipping apart of the layers due to pipeline movements (Table 1).

As a result, coextruded tapes are far superior to laminated tapes and have a much better long-term durability. "As has been proven and recognised in many areas, the use of high-quality materials and products in pipeline construction makes a big difference to value preservation and long-term operation. Using the right corrosion protection products from the start will generate immense cost savings in the years to come. These are costs that would become necessary if the pipeline had to be repaired due to low-quality corrosion protection", concludes Max Wedekind, Managing Director DENSO Group Germany.

Author

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DENSO Group Germany

Managing Director

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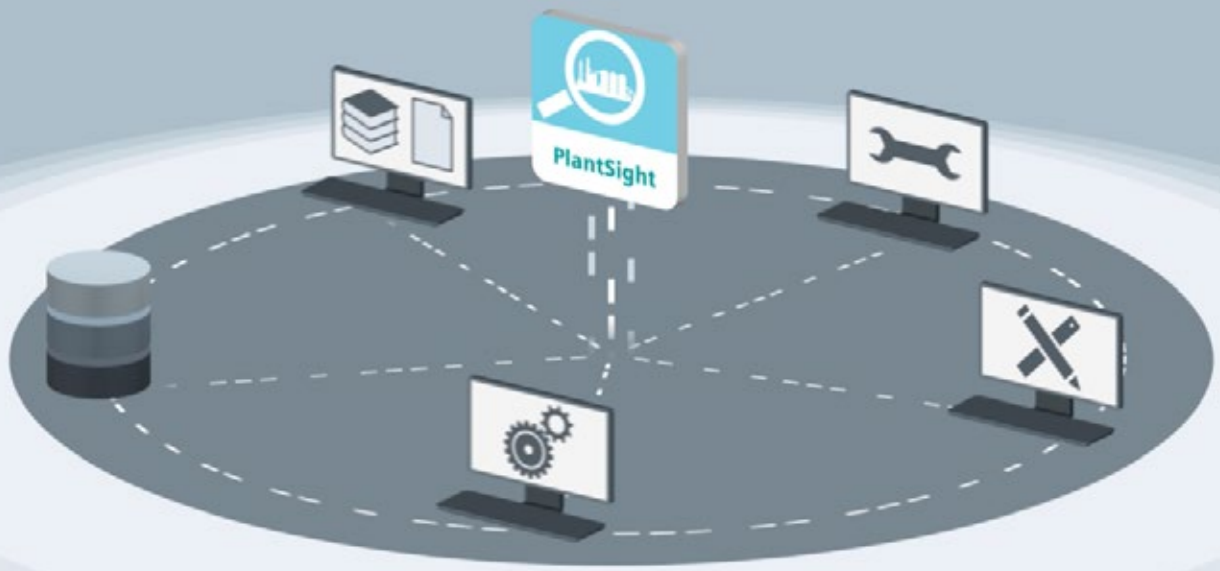
Paperless Integrated Plant Documentation – a dream or reality?



PlantSight is the cloud-based portal to all information - in a single environment.

Otmane Zraouti > Siemens Energy

Abstract

Documentation and data on existing brownfield plants/pipelines are often outdated, inconsistent, and widespread across multiple sources and applications. Whether it be engineering documentation such as process flow diagrams (PFD), piping and instrumentation diagram (P&ID), piping isometrics, circuit diagrams, loop diagrams, or operation and maintenance documentation like operation manuals, data sheets, service and maintenance plans, as well as Meta data, like important information regarding documents content (author. revisions, tagging, etc...), are not stored or even not available. In many plants the whole documentation is still in paper format, stored in archives, and often not as-built. Converting proprietary document types to intelligent digital format is very complex and usually only possible with manual redrawing. Also, the exchange of documents/ data across multidisciplinary teams and business partners is highly difficult.

All those hurdles make the operation, modernization, and the integration of digital documentation very challenging.

This white paper will provide a potential solution how the vision of paperless plant/pipeline documentation becomes reality. This paper will explain all necessary process steps, starting from collecting data, going through documents converting & linking up to consolidate all relevant documents of the plant/pipeline in one data source. With all those steps successfully executed it is possible to establish a centralized data center where all disciplines work together efficiently and to ensure a global collaboration of all project and team members. Additionally, access to an up-to-date documentation is possible via mobile devices such as smartphone and tablets anytime and anywhere.

1. INTRODUCTION

The dream of every pipeline operator is to get the whole plant data and documentations in one click. This is frequently referred to as the facility "digital twin", and is the digital representation of the physical facility that contains all the data of the assets and those related documents. Different types of documents can be included: models, technical reports, and business-related information. This digital twin is a prerequisite for paperless plant, as is the need to break down barriers between disparate silos of information that often still exist within most organizations.

The foundation for creating a digital twin is moving away from a document-centric approach, to having a data-centric environment for each asset or set of assets of the plant. A data-centric environment allows users to find what they want by starting with what they already know, since data is based on a single instance of objects which are related according to logical structures (Figure 1). For example, engineers onsite can easily navigate from any equipment like a pump to all relevant and related documents to support their daily work processes, without having to worry about duplicates or inconsistent documentation.

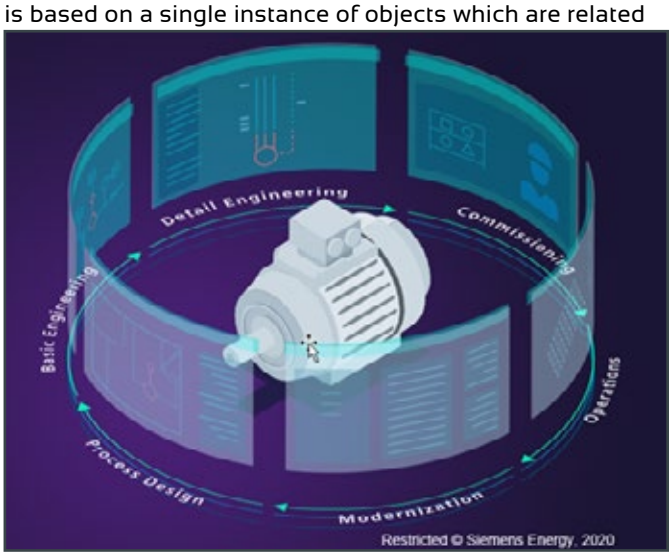


Figure 1: Single instant object-oriented documentation

This white paper will shed the light on digital twin from the documentation aspect, and the reasons why this lake of information grows, and provides different solutions to create a consistent and integrated documentation for a brownfield pipeline/plant.

2. CHALLENGES

Converting and upgrading pipeline or pipeline sections at existing production sites is especially challenging for plant engineers. Generally, projects of this type far outnumber greenfield projects – and managing the data and documentation is extremely complex. The data and documents are not consolidated and stored during the different phases from process design, detail engineering, to operation, and maintenance on multiple systems.

During the design and engineering phases, every department focuses on finding its own solutions, and delivering different types of documents which cannot be used after the handover to operation and maintenance. The following figure describes the currently common data and document flow of different engineering department.

Changes that have been made on the operation and maintenance over the years are often not transferred to the plant documentation, or only partially; all these factors lead to a big gap between the originally planned and the actual condition of the plant.

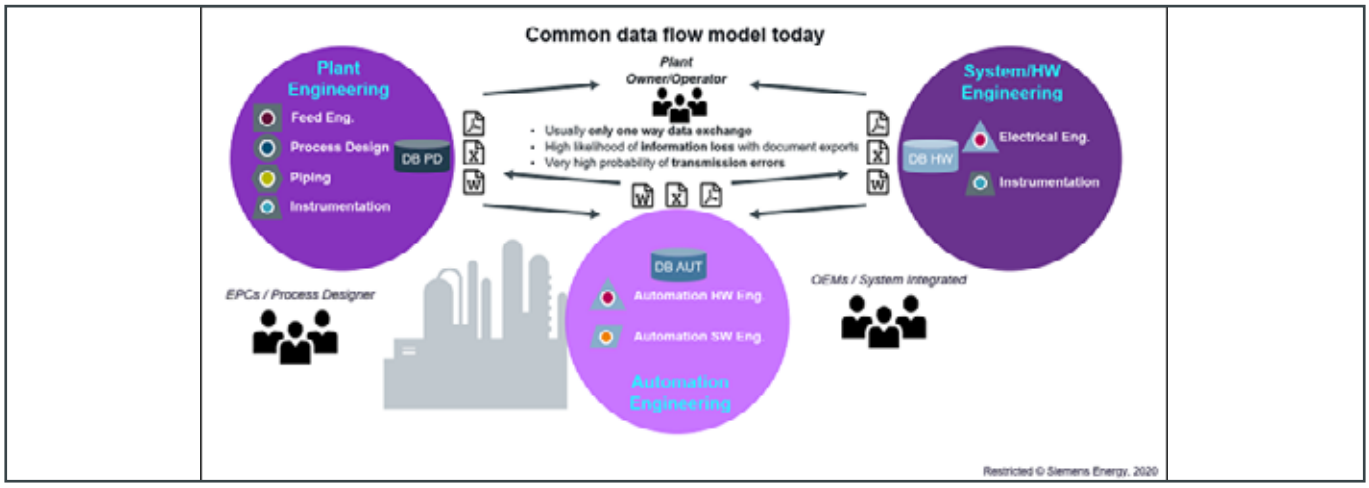


Figure 2: Common Data/Documents flow today on design and engineering phase

Pipeline operators are always faced with the problem where they have to bring the data from different data sources and get the right information and the last up to date version of document. Those challenges can be grouped on the following four major types.

Figure 3: Data Challenges

1. Data and documents are saved on different systems and under various formats: Excel, dwg, PDF
2. Missing meta data and tagging -> unstructured and unconsolidated
3. Unreliable plant data -> not a final version and unstructured
4. Storage in different systems result in data inconsistency

3. SOLUTIONS FOR PAPERLESS DOCUMENTATION

The major step to take for a useful paperless documentation is to centralize all documentation on one data source and basing it on contextualization to link it to the pipeline asset. Once those documents are collected and consolidated, the pipeline operator will be able to get those documents on one click. As a result, operation and maintenance tasks can be completed effectively on a digital way like web access or mobile solutions.

There are many approaches on the market that make this work possible according to customer needs. On the following chapter of this white paper, some of those solutions will be listed, and their impact for the improvement of the whole life cycle of the plant.

3.1. HOW TO BUILD PAPERLESS PLANT

The way to an intelligent paperless documentation is a long-term project. Go from searching for data to discovering data. Convert unstructured data into structured knowledge by liberating information trapped in documents, diagrams, images, video, and more. Make data discoverable, understandable, and comparable independently of its origins.

The project can be separated in two main parts documents collection and document validation. The first part consists to collect all plant relevant documentation from the different sources using different tool like extended document management system for example HxGN SDx from the company HEXAGON. The second step is making those document intelligent using contextualization solution like Cognite Data Fusion (CDF) [4].

Liberating the data/ documents and contextualizing it is the most complex part. Usefulness then requires that the data is findable when a user needs it. Different users will require different functionality from the big data lake. This is about navigating and viewing the data.

3.2. SMART DATA FOR BROWNFIELD

An integrated software solution like COMOS is mandatory for comprehensive plant management and offers custom solutions for brownfield enablement. Data and documents from a variety of sources can be centrally managed to improve maintenance planning and accelerate recommissioning.

The usage of a central data platform ensures consistent information and a seamless flow of all project-related data over the entire plant lifecycle. The solution for brownfield enablement allows you to quickly record, organize, link, and visualize large volumes of data and documents. The object-oriented data model and open system architecture make it possible to easily import data and documents (1D/2D/3D) from the engineering and operating phases to the plant lifecycle management system at any time.

The brownfield concept consists of 8 steps (Figure 4). Each of them can be applied individually and has its own benefits.

Figure 4: Smart data for brownfield steps (Source [1])

1. Create a objects structure tree based on customer's requirement
   The Structure can be created automatically by importing from database or excel.
2. Upload data and documents through web portal
   The document upload works for all kind of document

types. (Office; Drawings, PDF...)

3. Validate and consolidate data
   This is done Inside of COMOS by using its reporting capabilities
4. Analyze drawings and link to object structure created in step 1
   imported drawings will be linked to units or subunits and to single assets as well.
5. Analyze drawing content and link to object structure created in step 1.
   Tagged objects are linked to tags in the drawings or images using hot spotting.
6. Import 3D models from authoring tools or reality modelling
   3D Models from several sources are imported and can be managed.
7. Link 3D models to object structure
   Intelligent 3D Models can directly be linked using WalkInside. For Captured models the assignment of tag locations can be don automatically by an X,Y,Z import.
8. Convert imported documents in to intelligent documents
   Imported P&ID documents from different Process design tools can be converted semi-automatic or manually into COMOS P&ID's

Not every single step is necessary, and not mandatory in this order. Sequence can be stopped whenever it is preferred and continued seamless whenever needed.

3.3. WAY FROWARD TO A DIGITAL TWIN

The digital twin will become an advanced replacement to traditional paper-based handbooks and equipment documentation, ensuring that all relevant engineering data is held centrally in a single, interactive, and searchable solution. It will be built on a cloud-based architecture capable of processing live data and ensuring that vital engineering information is kept up to date at all times.

Industrial companies have so far invested in aggregating their data and making it available to their personnel, and that is usually done by using a cloud data warehousing set-up. To build an operational digital twin, this collected data must be put through a contextualization pipeline; a process that is both automatic and manual.

A strong operational digital twin requires:

- Multiple data sets & data types (unlimited)
- Multiple relationships between data (unlimited)
- Underlying principles of data vitality, data
- Openness, and data accessibility

These requirements are inspired directly by the needs of the human users of the technology, who care about different kinds of data and need different ways to navigate and view it.[4]

3.4. CLOUD BASED VISUALIZATION

Digital twin without cloud solution is today unthinkable. Digital solution like PlantSight (Siemens AG) or Intergraph Smart Cloud (HEXAGON PPM) are one of market-leading cloud solutions on for the industry. A scalable cloud architecture, web access, security concepts are the keywords for a digital solution to benefit customers through more efficient plant operations. Those solutions enables as-operated and up-to-date digital twins, which synchronize with both physical reality and engineering data, creating a holistic digital context to consistently understand digital components across disparate data sources, and for any operating plant.

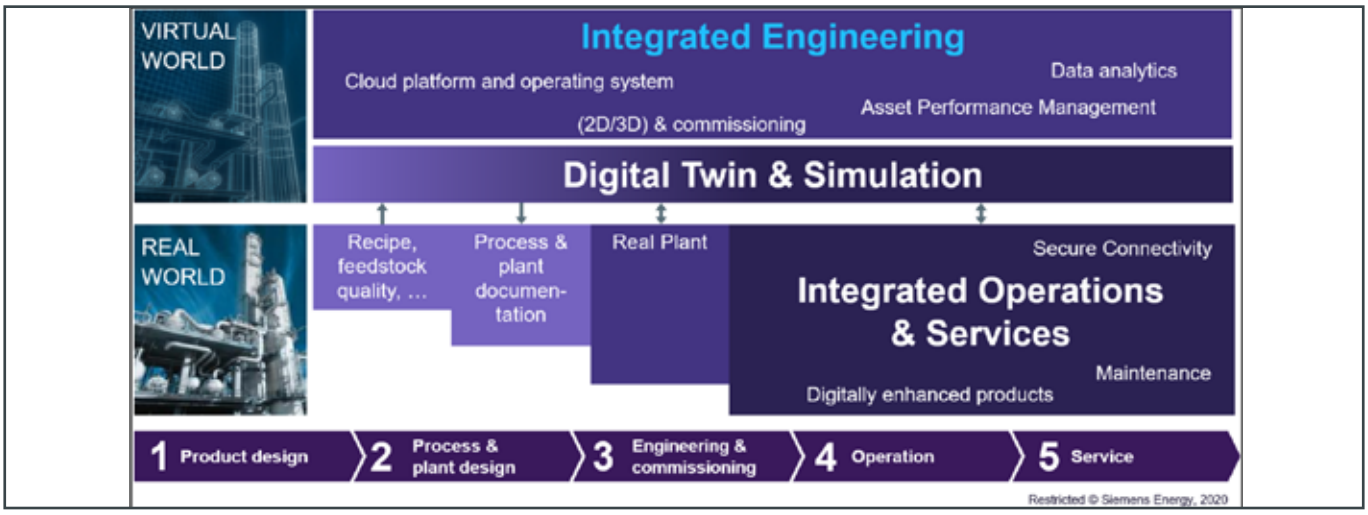


Figure 5: Digital Twin

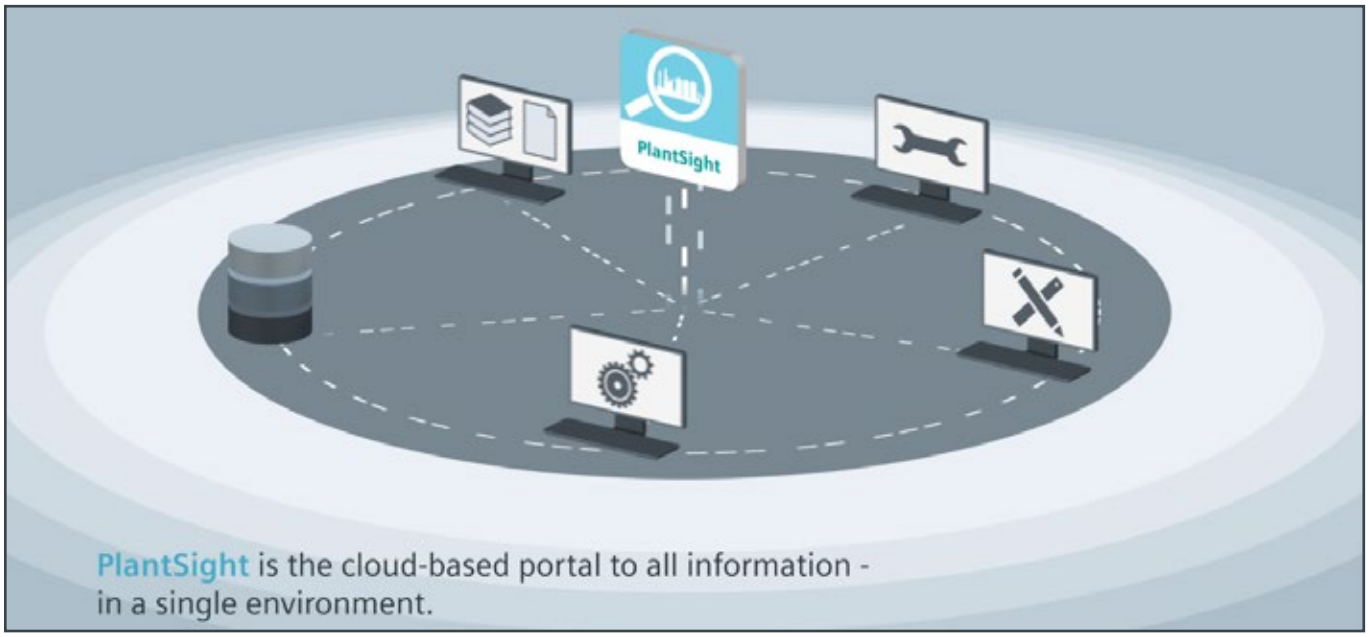


Figure 6: PlantSight - Cloud based visualization

With digital twin cloud services, operational and project-related engineering data are aligned seamlessly. All disciplines and stakeholders have immediate access to consistent representations. Especially for brownfield installations, the time and effort to federate and complete asset information will be significantly reduced with plant documentation kept up to date, and its quality accordingly improved.
"The base technology that we offer is iTwin Services that can take multiple data sources in the engineering space and digitalise and review sources on the web. From there we can build specific solutions and technologies for different industries. For example, in the traditional process industry, we have built a solution in partnership with Siemens called PlantSight that helps us move toward a more specific solution for oil and gas companies." [3]

3.5. ACCESSIBILITY

Accessibility is also essential for potentially powerful external partnerships. To integrate with proprietary data models from an OEM, the owner of the operational digital twin should use open APIs (Application Programming Interface) for consumption on top of the industrial data platform. This means sending private and secure API keys to authorized users, but also providing full and open documentation on the APIs themselves.

Additionally, documents are increasingly needed by people on the move. Reviews have to be performed on-the-go or data is required locally at plants. An integrated document without mobile solution is today unimaginable.

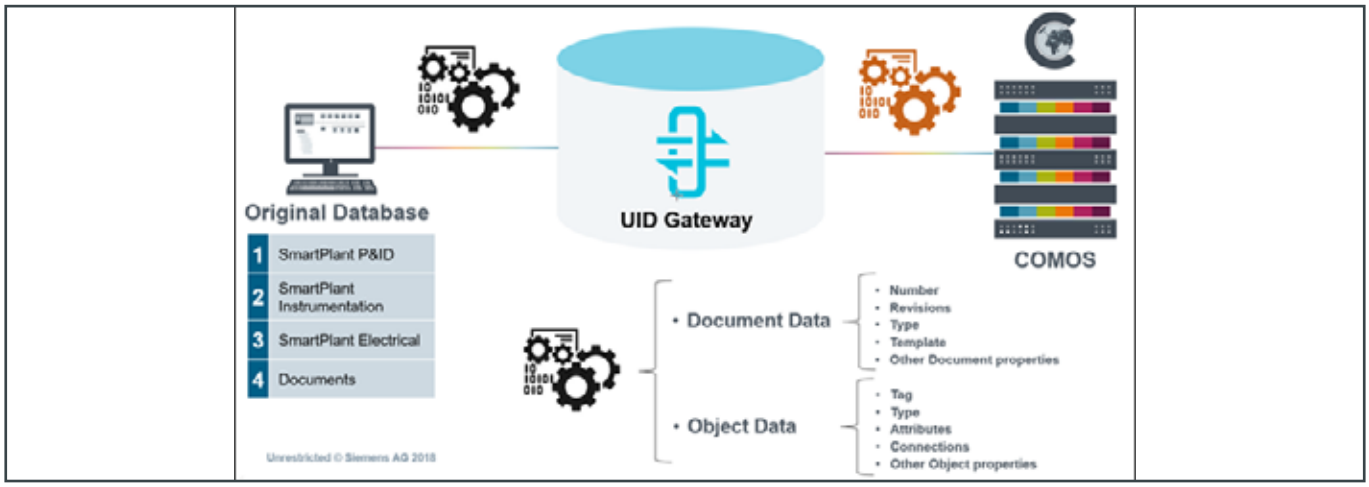


Figure 7: Digital Mine

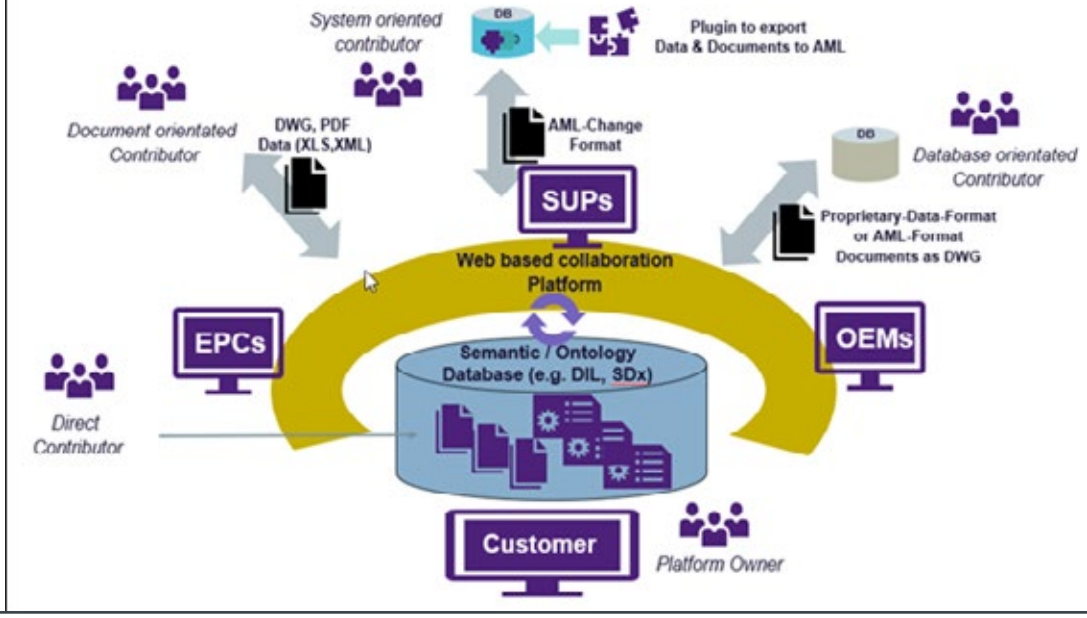


Figure 8: Collaboration platform

3.6. USE CASES OF PAPERLESS DIGITAL MINE

One of biggest project executed by Siemens Energy was the digital mine. Where we did usage of our know how to build up a holistic digital twin based on the migration of already existing engineering documentation created on Smart Plant on tree different DBs for differrent dicipliens (Process, Instrumentation and Electrical) to COMOS. The following Figure 7 show how the brownfield data/ documentations was migrated from the original DBs for different dicipiliens to one commun data base to be able the customer the usage of the digital mine later on for operations and maintenance.

Only a holistic approach to the question of documentation, including version and change management will provide all the benefits available from a paperless dream environment.

4. CONCLUSION

When transformation of data /documentation is done correctly, it is necessary to keep it alive and up to date, and this cannot be done by the operator, Supplier (SUPs), original equipment manufacturer (OEMs)/ Engineering, procurement, and construction (EPCs), nor by customer alone; it must be accomplished as a collaboration like shown on the Figure 8. We, as Siemens Energy, are working on different collaborations, in addition to new business opportunities to find suitable solutions for our customers. That requires us to be open, and to share our knowledge about how through co-creation, it is possible to build a new era of collaboration platforms as customer global solution for a paperless plant documentations.

References

[1] - https://new.siemens.com/global/en/products/automation/industry-software/plant-engineering-software-comos/empower-with-comos/smart-data-for-brownfield.html

[2] - Bentley's and Siemens' Vision for Cloud based Distributed Engineering and Operations (https://prod-bentleycdn.azureedge.net/-/media/files/documents/white-papers/extwp_arc_cloud_based_engineering_ltr_en_lr.pdf?la=de-de&modified=20180607111946)

[3] - https://www.pipelineoilandgasnews.com/interviewsfeatures/interviews/2020/july/ digitalisation-brings-greater-reliability-to-the-oil-and-gas-sector/

[4] - Operational Digital Twin: How Data Contextualization Provides A Complete, Actionable Understanding of Industrial Operations. (https://www.cognite.com/en/operational-digital-twin)

[5] - https://www.aveva.com/en/solutions/digital-transformation/digital-twin/

[6] - https://hexagonppm.com/offerings/products/hxgn-sdx-projects

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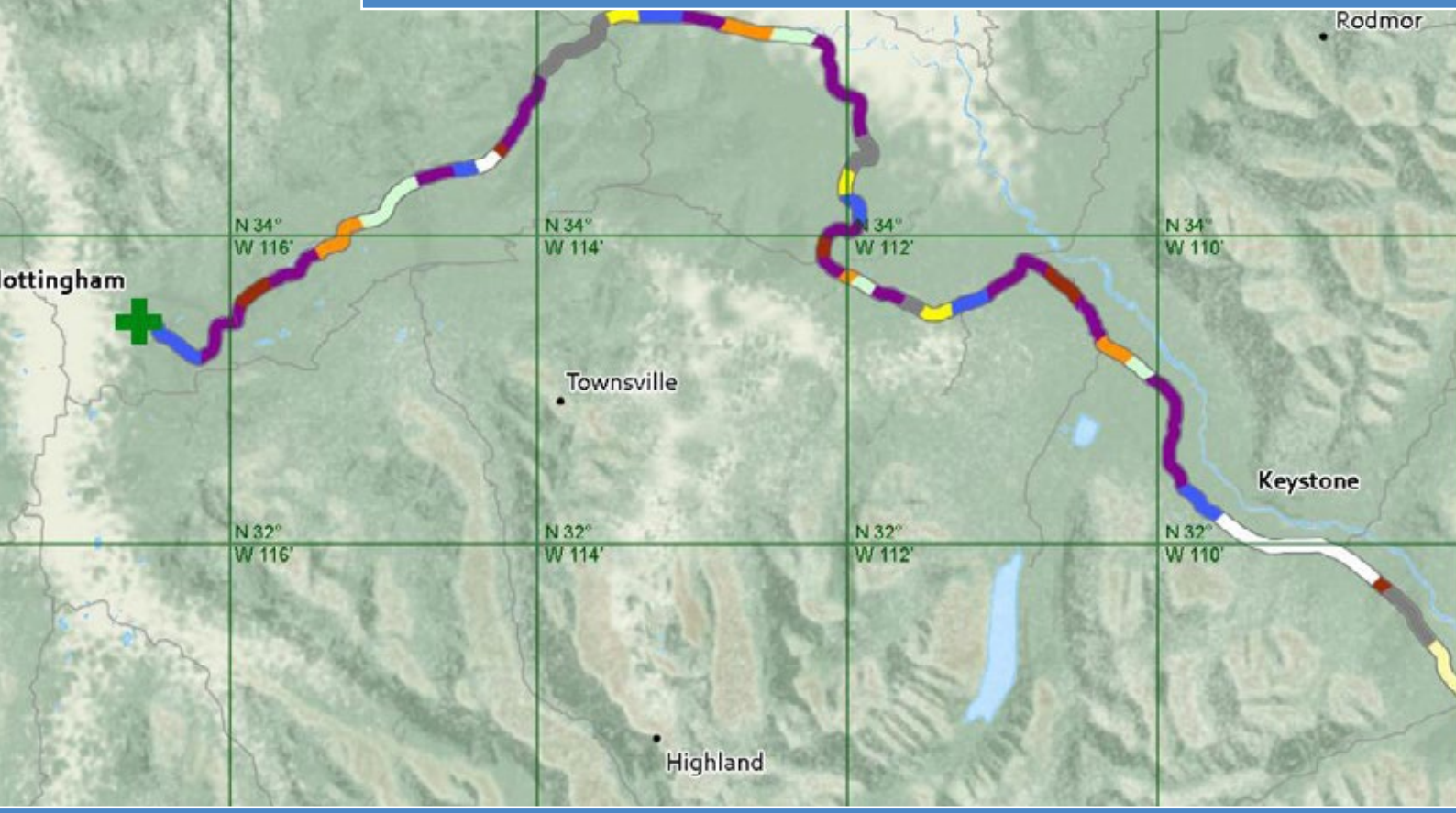
Using simulation to overcome operational challenges caused by the COVID-19 pandemic



Glen Tyson > Atmos International

Abstract

Atmos International (Atmos) is continuously working with the pipeline industry to develop solutions to overcome operational challenges. Atmos Simulation (SIM) Suite is an operational tool that users can trust to help operators run their pipelines safely, efficiently and with clarity and visibility.

Atmos SIM Online, working in real-time, performs a hydraulic simulation allowing pipeline operators to monitor all pipelines without the limitations of instrumentation availability. With Atmos SIM, operators benefit from fast and accurate simulations, providing meaningful information that operations teams can act upon quickly and with confidence.

The COVID-19 pandemic has caused additional challenges to pipeline operators and left some of them with reduced staff sizes. Operations teams with reduced members have used Atmos SIM to quickly identify faults with critical instrumentation. Atmos SIM enables them to isolate the issues by overriding the values with trusted simulated values. This helps users to continue to operate their pipelines with confidence while a maintenance team is dispatched and the problem is resolved.

Operating pipelines can be difficult, particularly if the product doesn't remain in the optimum region for efficient transport which is especially true when transferring varying grades of crude oil. Atmos Batch is an additional Atmos SIM module that allows operators to track, merge and blend their products while retaining and providing the information of the various component fractions of the batches and calculating its new physical properties itself to ensure the product reaches its destination safely and efficiently.

Atmos continuously innovate and improve its solutions including Atmos SIM and provide excellent customer care to our global customer base.

1. PIPELINE SIMULATION

The discipline of pipeline simulation can be summarized as the use of computational modelling to create an accurate representation of an actual pipeline system. This virtual replication of a pipeline is a powerful tool that has numerous applications in design, operations, training and management for the user's pipeline assets to enable them to operate their pipelines more safely and confidently while reducing costs.

Atmos SIM is an operational tool that users can trust to help operators run their pipelines safely, efficiently and with clarity and visibility. Atmos SIM is comprised of various software products and modules like Atmos SIM Online, Atmos SIM Offline, look-ahead modelling, Atmos Batch, Atmos Trainer and others.

Atmos SIM Online is capable of modelling either liquid or gas pipelines using real-time data available from DCS and SCADA systems. It enables operators to monitor areas where there is limited or no instrumentation and can complete forecasting calculations which allow operators to view the future pipeline conditions based on current or simulated (what-if) conditions and assess the safety of the schedule.

From exploring the initial pipeline design and providing justifications or validations to specific design decisions, simulation systems are commonplace in the early stages of pipeline construction or expanding existing systems. When working from a blank canvas, pipeline design specialists can work quickly to explore different ideas and virtually experience the different operational and commercial effects from their varying designs, allowing them to deliver justifications and validations to the recommended designs. Pipeline simulation software accelerates this entire process, enabling a wider range of design trials that will ultimately yield significant cost reductions.

Simulation offers pipeline operators in a live environment an amazing tool that enables them to explore the effect of operational changes and measure their impact in a virtual environment without having to risk implementing changes to an active pipeline system. Utilities help optimize pump/compressor operating plans to minimize running costs and reduce emissions. From an operational standpoint, operators can see the effect that any unplanned maintenance will have on the system and be able to respond effectively to any resulting negative impact.

Where pipelines are transporting multiple products with the same asset, the operator can monitor the status and properties of their products with Atmos Batch. Atmos Batch is widely regarded as the most accurate batch-tracking tool in the market, uniquely effective for long pipelines with large elevation changes and prominent vapor pockets. The batch tracker provides a rich and accurate visual display reporting all relevant details of value helping the operations team to optimise the process.

Simulation also offers a powerful training tool to improve operator onboarding to allow them to gain the experience required through a simulated pipeline.

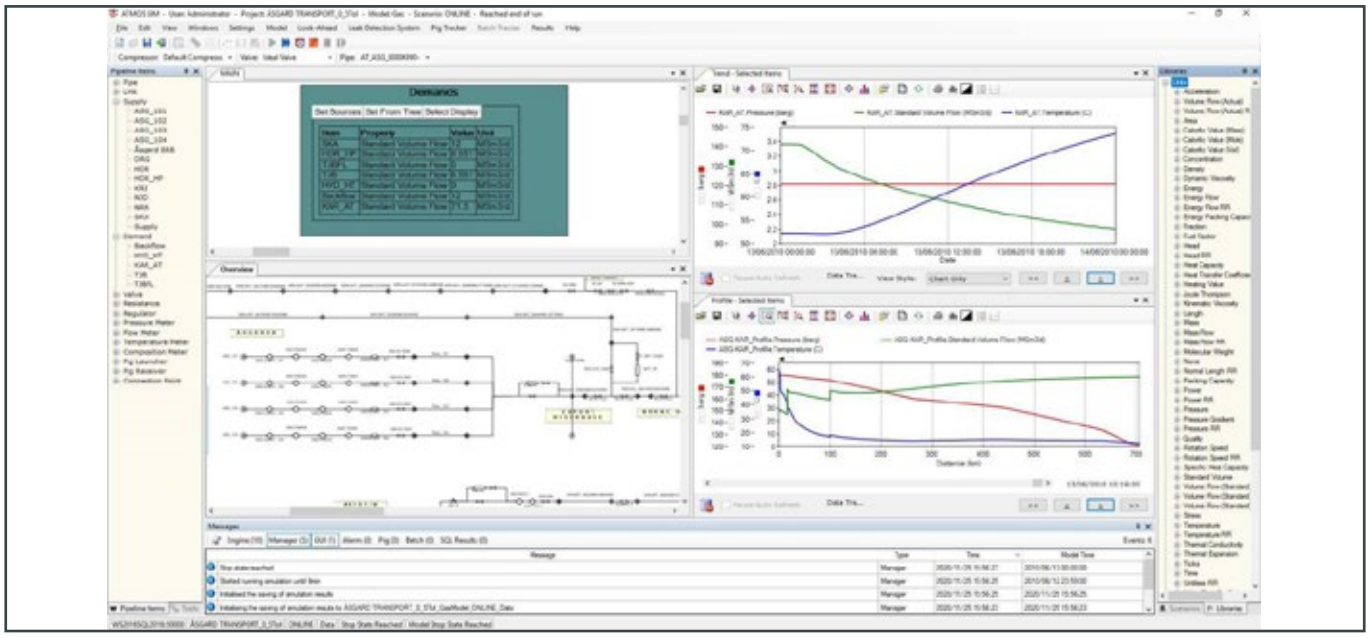


Figure 1: Real-time simulation results of a pipeline network

Atmos SIM pipeline modelling software, in general, has various applications, the focus of this paper is its ability to improve pipeline operations and to share how Atmos SIM systems are helping those in the control rooms, throughout the world, utilize pipeline simulation to deal with the additional challenges presented by the COVID-19 pandemic.

COVID-19 has changed how organizations operate by restricting the way we work to maintain a safe working environment. The current reality is that operational teams are having to work with a smaller amount of resources and are expected to deliver the same level of services as before the pandemic. The solution for Atmos SIM users has been to place more focus on their real-time models and some have begun to integrate them more closely within the operating process. This is a trend we expect all users of pipeline simulation software to be doing for those fortunate to have it available. Doing this enables operators to make informed decisions faster, reducing time to resolution of quickly evolving situations, it provides an extra pair of eyes overlooking the system and automates some of the more time-consuming tasks.

Figure 1 shows an example of the simulation results in time and distance-based profile of flow, pressure and temperature.

INSTRUMENTATION ANALYSIS

One of the key benefits Atmos SIM customers are reporting is the instrumentation analysis functionality. This feature is standard for Atmos SIM to ensure the model is always returning accurate results. Atmos SIM achieves this by comparing real-time data acquired from field instrumentation with the calculated results which are returned from the simulated pipeline model. When this comparison returns a difference, Atmos SIM can determine if the field instrumentation has developed a fault as it can benefit from the surrounding instrumentation values and not focus on the difference in isolation and identify the value as an outlier. An example of this can be seen in Figure 2.

It is this comparison that Atmos SIM users have taken to the next level. Following the identification of faulty instrumentation in the field, it is not always possible to dispatch a repair team promptly due to availability or even having the essential equipment to complete the repair. In this circumstance, users have been able to integrate the simulated values into the SCADA/DCS and override them in human-machine interface (HMI) displays to enable the operations team to safely operate without the need to constantly note which values are unreliable.

In the example in Figure 3, a redacted image of one of our user's systems is shown, where the unreliable values from the field have been replaced with simulated values and highlighted to provide that visual cue to remind them of its source.

This process also allows the operations team in the control room to easily prioritize the dispatch of the maintenance personnel to quickly resolve high impact issues. Before this integration, the control room would have been reliant on the systematic approach to the maintenance of each instrument which would have been done on a schedule rather than this proactive approach to the issue documented above. Figure 4 below illustrates how being able to compare the modelled and actual data provides a clear indication that some maintenance is required.

Figure 2: Real example of a trend showing three different pressure meters with the SIM calculation shown in a continuous line and measurement shown in a dashed line

Figure 3: An example showing the measured values are replaced by simulated ones (inside the red rectangle)

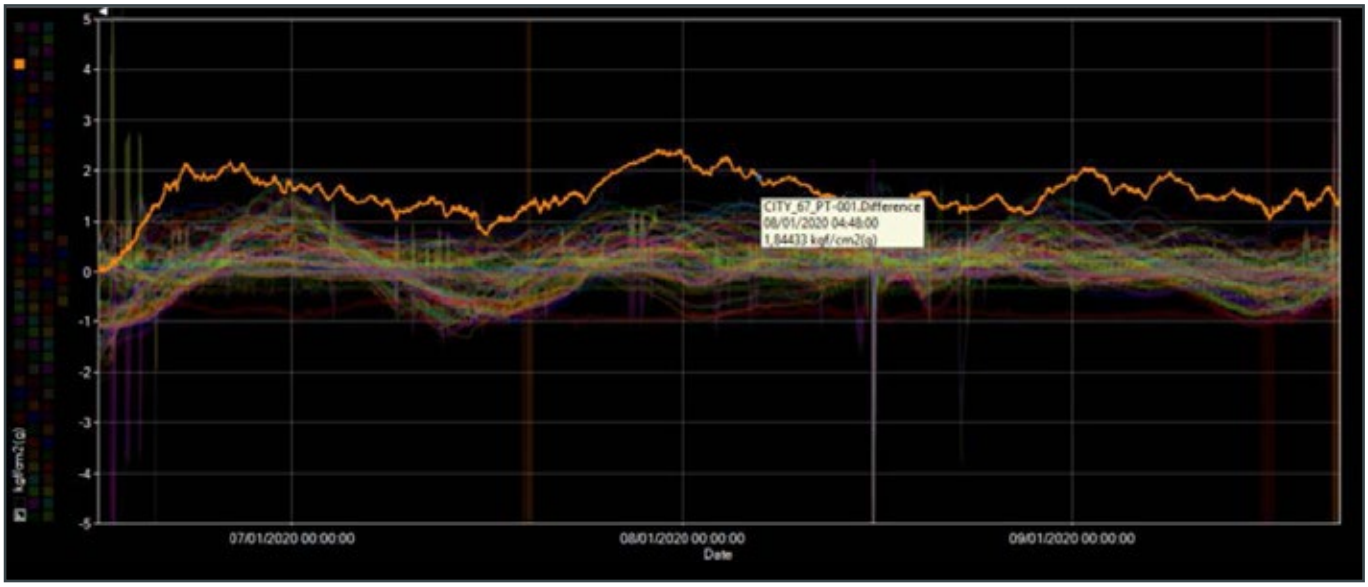


Figure 4: Difference between measured and calculated pressure indicating a need for instrument maintenance

ISSUE PREVENTION/PROBLEM AVOIDANCE (LOOK-AHEAD)

Atmos International is known within the industry for the leading leak detection solutions and it is sometimes easy to overlook the value of pipeline simulation as an element of leak prevention. Atmos SIM can foresee developing issues and provide early warnings hours before any action is required to avert a crisis with the 'look-ahead' feature.

With a real-time model in operation, the simulation software can take a 'snap-shot' of the current pipeline state and calculate what will happen in the future if the operating conditions remain the same and return alerts if pipeline limits are to be exceeded and a predicted time when this would occur. Similarly, it can forecast if a nominated schedule is feasible by running look-ahead modelling. This type of operation can be manually triggered but it is typically automated to run as frequently as every 15 minutes for short term calculations in the region of 4-6 hours ahead to every hour for longer-term calculations. Results are returned within minutes and using the latest technologies Atmos SIM can process multiple simulation scenarios simultaneously so that the operators have fast accurate information that they can act upon proactively with confidence rather than making reactive decisions to an unfolding disaster.

PIPELINE TRACKING INFORMATION

Pipeline simulation delivers added benefits when used in conjunction with operational tracking needs such as real-time batch tracking. With the use of the simulation model, Atmos Batch can handle complex calculations such as batch blending and compute changes in the product properties as they happen, such as the changes in viscosity from two different crudes and also continue to track the makeup of the composition of this newly blended batch. Even if further batches are injected, the simulation can automate the calculation of all the components for the new batch and continue to compute new properties for this. The ability of the model to optimize itself to ensure its results are accurate as operating conditions change, such as large elevation differences, varying pipe diameters and low-pressure sections means that the batch tracking system can reliably predict a batch arrival within a small window of time ensuring the operators are ready to deliver the batch to the right storage tank minimizing the mixing and waste.

All of this results in less time and resources spent on manually tracking these elements with the flexibility of auto adapting to changing operating conditions and also reduces the time needed to be allocated to managing batch arrivals due to accurate ETAs. Figure 5 shows an example of batch tracking in two parallel pipelines. Figure 6 includes the details of a batch tracking system for a long multi-product pipeline.

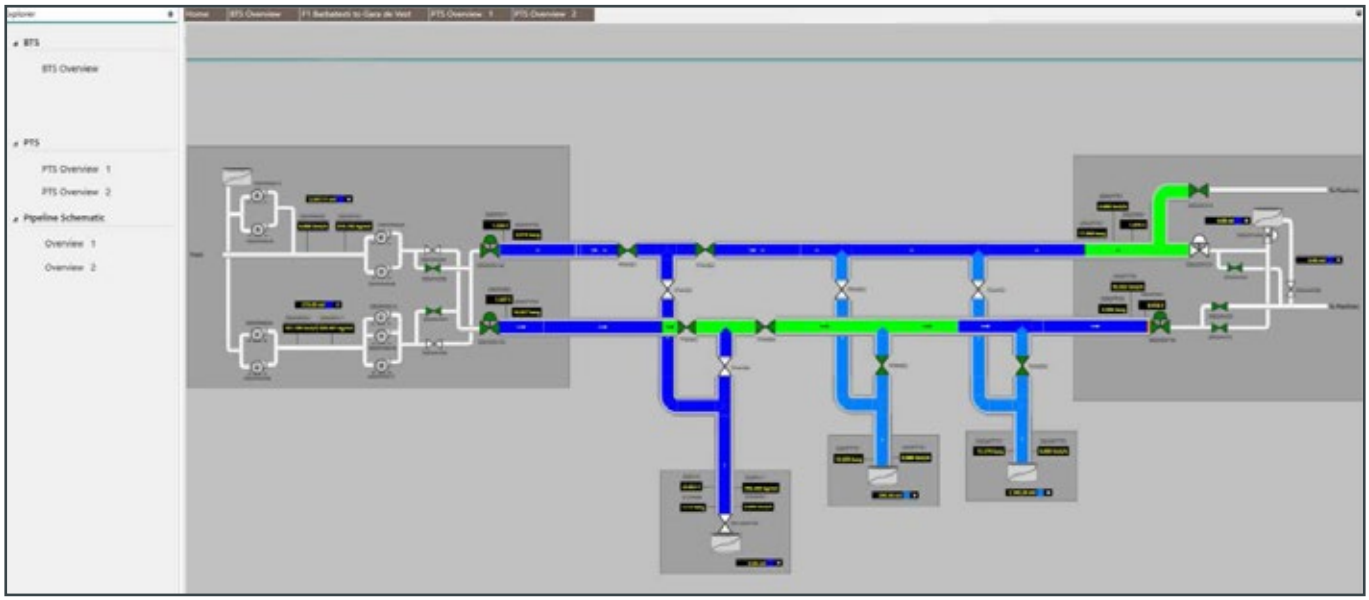


Figure 5: Batch tracking in two parallel pipelines

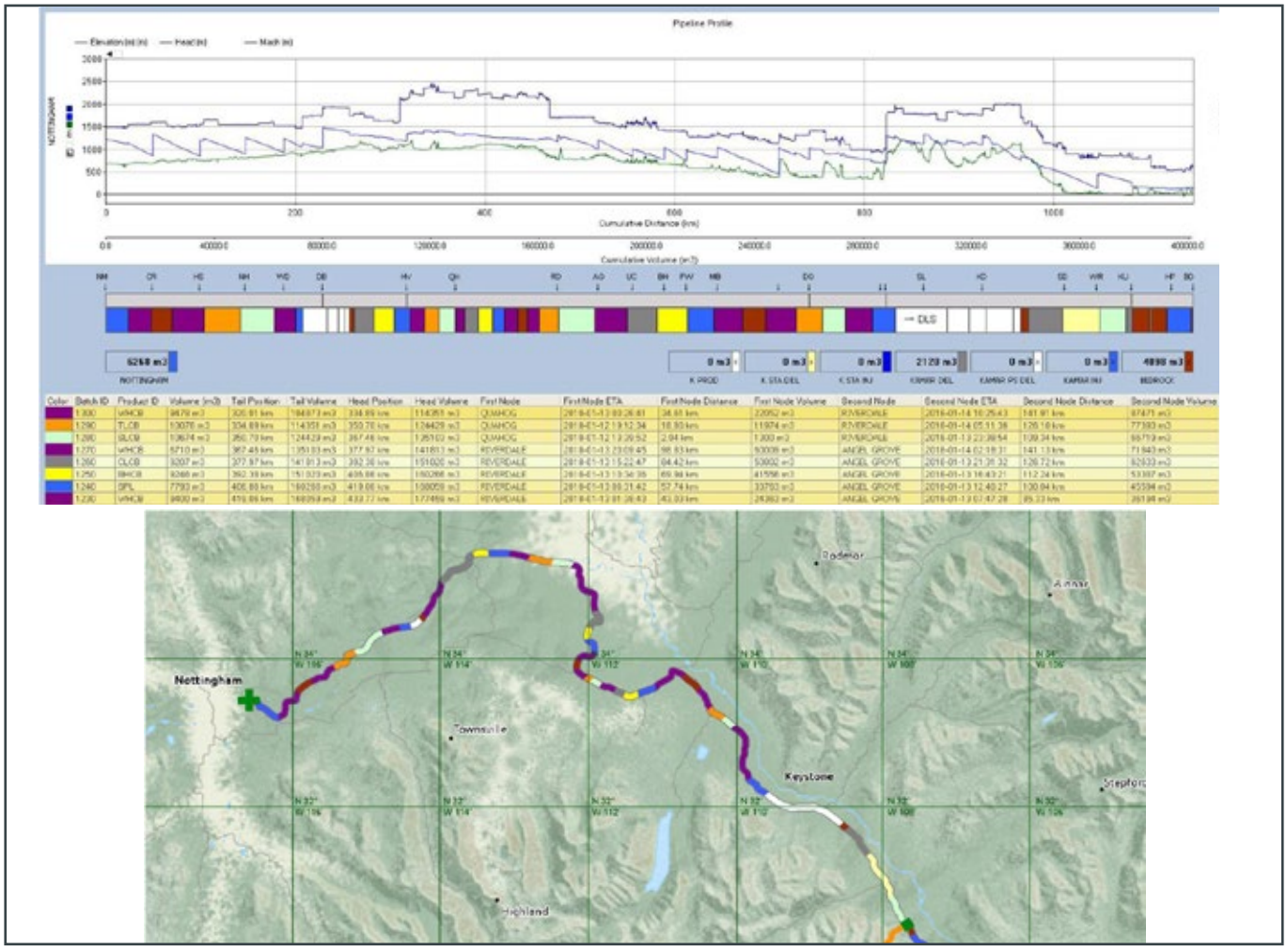


Figure 6: The details of a batch tracking system for a 1400 km long multi-product pipeline

CONCLUSIONS

What has traditionally been a tool for a specialized simulation department (with its dedicated experts) has been shown how critical pipeline simulation is for pipeline operation and control. It is clear how entire pipeline operation teams could benefit from an 'extra pair of eyes' in the form of simulation with Atmos SIM.

Atmos instrumentation analysis aids the fast identification of instrumentation faults that have developed in the pipeline network. This enables operators to make an easy assessment of the issue and provides them with more options when deciding what action is required. Atmos SIM also supports the integration of the simulated values into the SCADA/DCS to allow further flexibility to overwrite poor quality data in the interim period it takes to fix the instrument.

Other features such as 'look-ahead' and Atmos Batch help provide a single source of truth for what is happening over every inch of the pipeline. These tools also automate certain tasks ultimately providing operators with more time to dedicate to the other necessary tasks while giving them the confidence that they are operating the pipeline efficiently and safely. None of this can be achieved without having a capable system that the users can trust. This trust is built on the foundation of a robust, accurate model that is extremely reliable that supports user's day-to-day needs.

Without Atmos SIM an operator's job becomes harder, slower and considerably more stressful in these already challenging times.

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Digital Communication for safety of water pipelines - Case Study German Harzwasserwerke GmbH on the use of the BIL-Portal for pipeline enquiries

Ullrich Britz; Nils Harms; Jens Focke > Harzwasserwerke GmbH; EnergieSystemeNord GmbH; BIL eG

Abstract

How the BIL-portal delivers significant value to an infrastructure-network carrier in efficiently processing planning and construction enquiries from third parties.

A portal connection and communication process without media discontinuity leads to lower enquiry volume with simultaneously increasing number of relevant enquiries and allows digital processes, which built upon existing systems.

Harzwasserwerke is the largest pipeline operator in northern Germany on water transmission from its resources in the mid of Germany to the large cities in the region. The integration project delivers direct value after start of the COVID19 -pandemic allowing external access to data used in an enquiry process.

1. BASELINE: INCREASING CONSTRUCTION ENQUIRIES AND RESOURCE-INTENSIVE PROCESSING

Company and problem definition:

Harzwasserwerke GmbH (HWW) operates 530 km long-distance water pipelines connecting customers and suppliers in Lower Saxony and Bremen in northern Germany. As a pre-supplier, HWW supplies around 70 towns, municipalities and water associations in the geographical triangle Göttingen-Wolfsburg-Bremen, which then transport the drinking water to the consumer. From the headquarters in Hildesheim and at 20 other locations in Lower Saxony, around 250 employees do their utmost every day to ensure that water flows through the interconnected system. Large parts of Lower Saxony and Bremen thus receive high-quality, soft drinking water, most of which comes from the reservoirs in the Harz Mountains and is treated in the company's own waterworks. The infrastructure is thus a central hub of the northern German water supply and requires particularly high safety standards.

As a transmission system operator, Harzwasserwerke GmbH receives a large number of planning and construction enquiries from third parties. In 2016, there were more than 1,200. In previous years, the volume of enquiries increased by around 10-15% year on year (see also Figure 1). The increase resulted from the density of enquiries in the overall market, which has risen continuously.

Pipeline safety and supply security is a top priority for the transmission system operator. Preventive measures, such as line information to avoid damage caused by third parties, therefore play a key role. The increased number of enquiries and the need to respond manually, especially those that are not relevant (so-called zero notices (Nullbescheide) - share approx. 70-80%), resulted in very personnel-intensive and time-consuming processing. Since 2015, as a first optimisation approach, a specialised process developed by the IT service provider EnergieSystemeNord GmbH (ESN) has been used to process the enquiries in a central information system with the help of BPM technologies and the specialised application LISnovus. This specialised process controls the processing and archiving of the enquiries. Through the specialised process, the processing of zero notices could be significantly simplified, but it is still an effort, especially in the context of the documentation of the information process.

2. SOLUTION: PORTAL CONNECTION AND COMMUNICATION PROCESS WITHOUT MEDIA DISCONTINUITY

Against this background, Harzwasserwerke GmbH continuously examines the existing process and system workflows and looks for optimisation potential. For example, in the age of digitalisation, to identify and implement optimal and media-interruption-free communication channels. Particularly with the high number of line information requests and their very different qualities and sources, there is considerable potential here for increasing the effectiveness of the response process.

Since joining the BIL-portal in 2020, the HWW has only received standardised, complete enquiries through this source and only those that concern it according to the areas of responsibility it has defined. Only one technical question had to be clarified: whether the processing and answering of the enquiries in the BIL-portal should be carried out autonomously and manually within the portal with the functionalities available there or whether the specialist

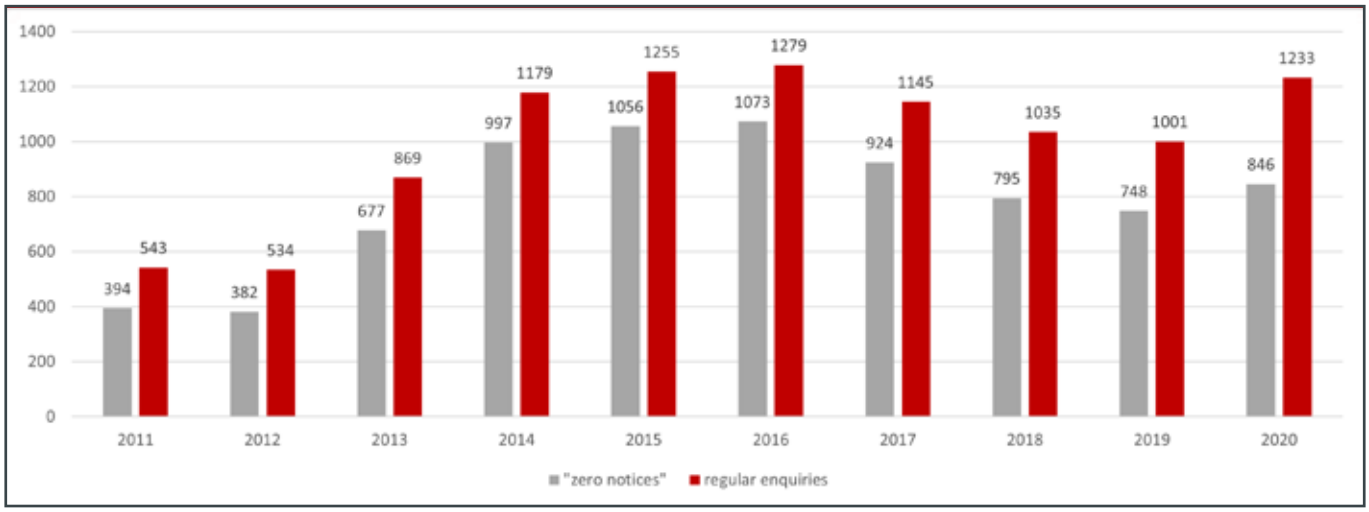

Figure 1: Enquiry volume of Harzwasserwerke GmbH in the period 2011 to 2020 (Source: Harzwasserwerke GmbH)

process with web-GIS coupling in use at the HWW should be fully connected via the standard BIL interface.

The existing specialist process "building enquiries" is mapped in the WEB application LISnovus for controlling the statements within the framework of the information process in the company. Through the further connection with the document management system (ELO) used in the company, the notices and workflows are now also documented centrally.

With the requirement that the business processes at Harzwasserwerke GmbH should be carried out as efficiently and standardised as possible, the decision was obvious: construction requests submitted to the BIL-portal are automatically integrated into the established process in LISnovus. Both IT systems are optimally networked with each other digitally and without media discontinuity. The option that alternative processing is possible at any time within the BIL-portal is nevertheless considered very positive by Harzwasserwerke and is kept as a potential backup option. With regard to today's need for digitisation, the approach described above has more than proven itself. The consistent storage of the data on the enquiry, the process steps and the contents of the response on a neutral and secure server also enables freedom from contradictions and legally secure verifiability in the event of a claim. For those seeking information who are not yet able to join the digital process, the request option directly to Harzwasserwerke GmbH remains available in parallel.

3. IMPLEMENTATION: LOW EFFORT AND PROBLEM-FREE INTEGRATION IN THE ONGOING OPERATIONAL BUSINESS

In coordination with the IT service provider EnergieSystemeNord (ESN), the standard interface of BIL was adapted to the needs of HWW and seamlessly integrated into the existing processing workflow. The expenses and costs for the customisation and implementation of the BIL-interface were extremely moderate in view of the expected benefits for the overall process and its optimisation potential and were quickly compensated for by the high increase in efficiency.

The complete implementation of the interface took only a few weeks and was available in time for the productive start. The internal effort at HWW was low and could be covered without any problems in the ongoing operational business.

4. RESULTS: LOWER ENQUIRY VOLUME WITH SIMULTANEOUSLY INCREASING NUMBER OF RELEVANT ENQUIRIES

The desired process-related improvements were achieved as soon as the system went live. Since then, enquiries that reach the HWW automatically via the BIL-portal can be processed directly in a quality-assured manner, without the need for time-consuming manual localisation and recording in the HWW's own web GIS system. At the same time,

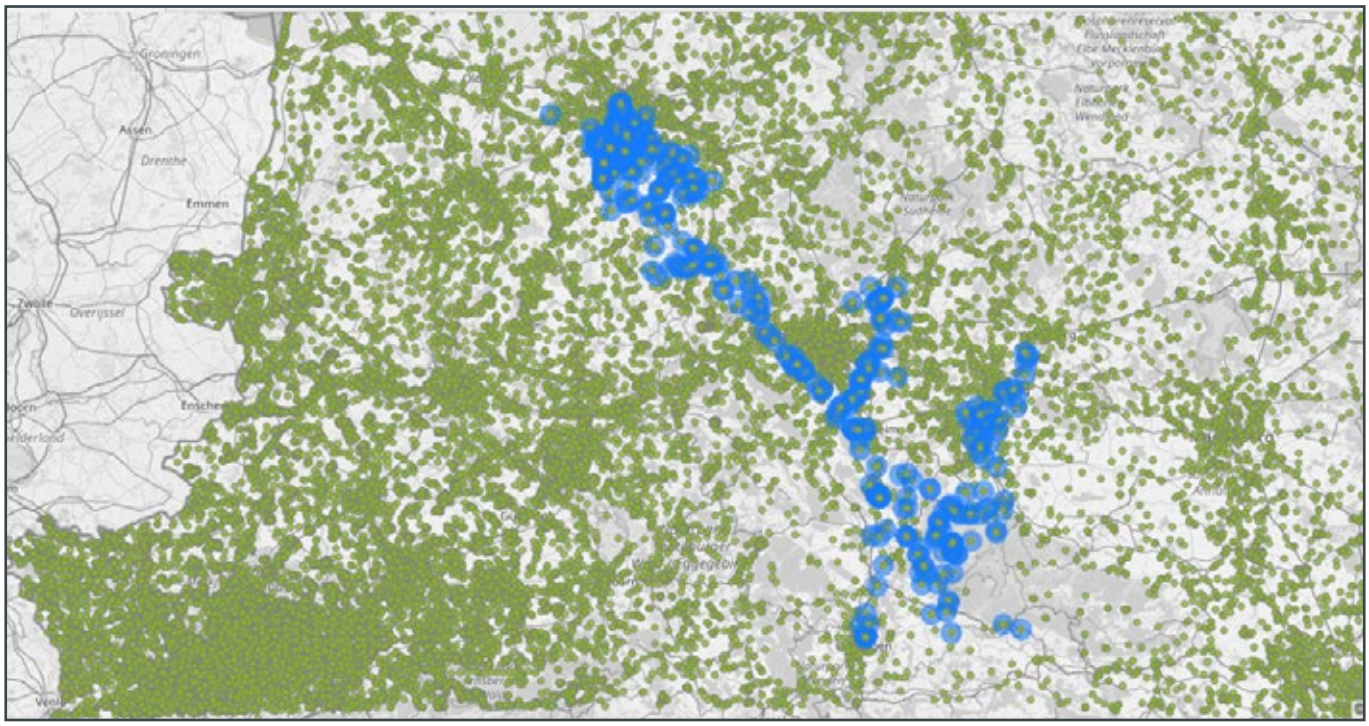

Figure 2: Requests received by Harzwasserwerke GmbH via the BIL-portal (blue dots) vs. requests received in the BIL-portal (green dots) for the years 2020 and 2021. (Source: ©OpenStreetMap, Harzwasserwerke GmbH, BIL eG 9/2021)

the enquiry volume is reduced to the requests coloured blue in Figure 2.

The results in detail:

a) Fewer construction enquiries are received by Harzwasserwerke GmbH. With the connection of the BIL-portal, the number of construction enquiries received by the HWW decreased significantly. This applies in particular to the previously received, non-relevant enquiries, which had to be answered manually with a zero notice, which required considerable resources. These are now automatically generated by the BIL-portal. This reduced the total volume of enquiries received by the HWW from 2020 by around 30 percent (Figure 2).

b) The number of relevant building enquiries is increasing. In turn, the HWW now receives a significantly increasing number of relevant hits as a result of incoming enquiries via the BIL-portal (Figure 3).

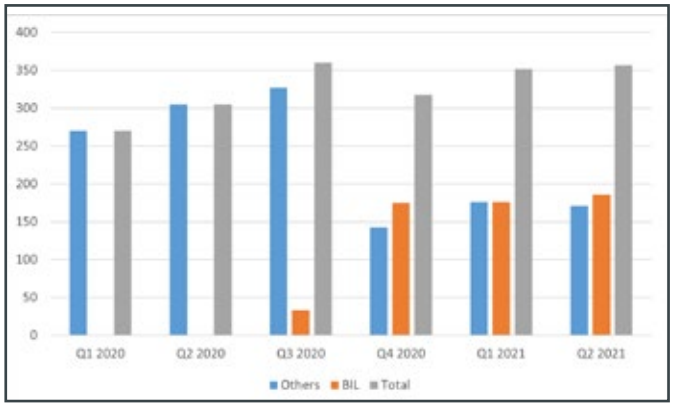

Figure 3: Development of enquiries and their qualification before and after connection of the enquiry process to the BIL-portal after Q3/2020 (Source: Harzwasserwerke GmbH)

This is where the advantages of the BIL-portal become obvious. Because many "critical hits" that could threaten the pipeline network of Harzwasserwerke GmbH now reach HWW, where they were previously "overlooked". These can now be identified immediately and answered in a quality-assured manner, so that the effectiveness of this preventive measure is directly noticeable for both the HWW and construction workers. The volume of enquiries changes in favour of an increase in safety-relevant affected enquiries with automatic elimination of non-relevant enquiries by the BIL-portal.

With the connection to the portal, a number of positive effects have thus been achieved immediately. Due to the decrease in unaffected, irrelevant enquiries (Figure 4) and the simultaneous increase in relevant enquiries for Harzwasserwerke GmbH, the employees can now concentrate more on the essential core tasks, such as the prompt and qualified examination and response to affected and standardised enquiries.

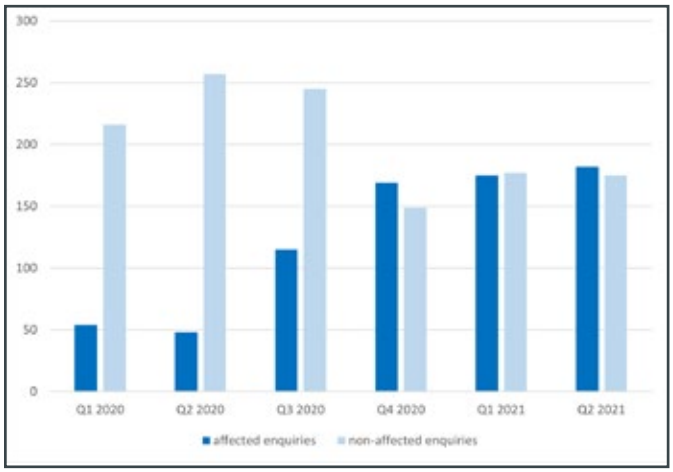

Figure 4: Affected enquiries (dark blue) vs. non-affected enquiries (light blue) of Harzwasserwerke GmbH for the period 2020 to 2021 (Source: Harzwasserwerke GmbH)

A further improvement is expected when the first enquiries from public authorities are forwarded via the BIL-portal and checked for competence. An adaptation of the specialist process is currently being implemented and has gone live at the HWW in autumn 2021.

There are also clear advantages for the building enquirer, as he is immediately informed in the BIL-portal whether or not the HWW is in principle affected by the measure. This speeds up the enquiry process.

The HWW itself also benefits from the advantages of the BIL-portal as an enquirer. This is always the case when, in the course of their own construction or maintenance measures, third-party pipeline investigations have to be carried out and these can now be done conveniently via the BIL-portal and the additional ALIZ research service integrated in the portal.

5. POLICY RECOMMENDATION: PROCEDURE IN THE CONTEXT OF THE REGULATIONS BY MEANS OF DIGITAL COMMUNICATION

The pipeline information process is practised by Harzwasserwerke GmbH in compliance with the relevant regulations. Already at the beginning of the project, the contents of the current version of the working paper on the meta-systematics of pipeline information (DVGW GW115; DVGW is a recognized standardization body for the gas and water industry) have been implemented, which define the recommended parameters for the formulation of a construction request to prove the legitimate interest. The specification allows the HWW to answer without consulting the enquirer.

In the course of selecting a suitable information platform for the HWW, an examination was carried out with regard

to a digital evidence procedure for external information processes (DVGW GW 118 "Transmission risk"). These characteristics result from the use of digital portals, which integrates all market participants for this purpose and represents a higher degree of operational safety security for the water pipeline operator. In the BIL-portal, the individual activities for the information process are automatically and unalterably documented by the system and archived for up to 30 years. The information process via the BIL-portal does not send network information by e-mail, but only informs the person seeking information about the provision of network information in the portal, which the information seeker can download. This system transfers the transmission risk to the person seeking information and recipient of the network information. Accompanying formulations in the terms of use of the portal participant should point out this aspect.

In this way, the BIL-portal ensures in every case that the information reaches the recipient and that this is clearly documented for all parties involved in the information process.

6. PERSPECTIVE: DIGITISATION OF ENQUIRIES COMING FROM PUBLIC AUTHORITIES

Currently, the volume of enquiries via the BIL-portal at Harzwasserwerke GmbH is more than 50 percent of the total enquiry volume. However, the majority of the construction and planning enquiries that still have to be answered conventionally are enquiries from public authorities. These official enquiries account for about one third of the annual enquiries and the processing is very time-consuming. In most cases, there is ultimately no concern. However, with regard to official enquiries, positive effects can be expected in the future as a result of the announced digitisation offensive. The following goals have already been defined in the government programme "Digital Administration 2020":

- The vision of e-government is that information, communication and transaction processes between politics, administration, citizens and the economy can take place from any place, at any time and with any medium, quickly, simply, securely and cost-effectively.
- The goal is to take a look at relevant processes in their complexity from start to finish in order to implement them in a networked way, sharing work with others and using common infrastructures.
- The programme "Digital Administration 2020" aims to use modern information technologies to establish digitalised, end-to-end, media-independent, uniform and public service provision based on collaborative business processes.

In this respect, BIL eG and tetraeder.com GmbH have taken the foresight to cooperate in advance and have systematically coupled the BIL-portal and the Public Planning Information and Participation Server (PB) from tetraeder to hand official planning request from public authorities.. The interface between the two portals went live in July 2020. Since then, the first authority requests have already been forwarded via the BIL-portal and checked for relevance. A promising perspective for the future.

A broad use of the BIL-portal across all pipeline networks means a security benefit for the sensitive infrastructure in Germany and is an important step towards digitalisation and process improvement for pipeline enquiries and a simplification for the enquiring civil engineer.

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Going ahead for Safety

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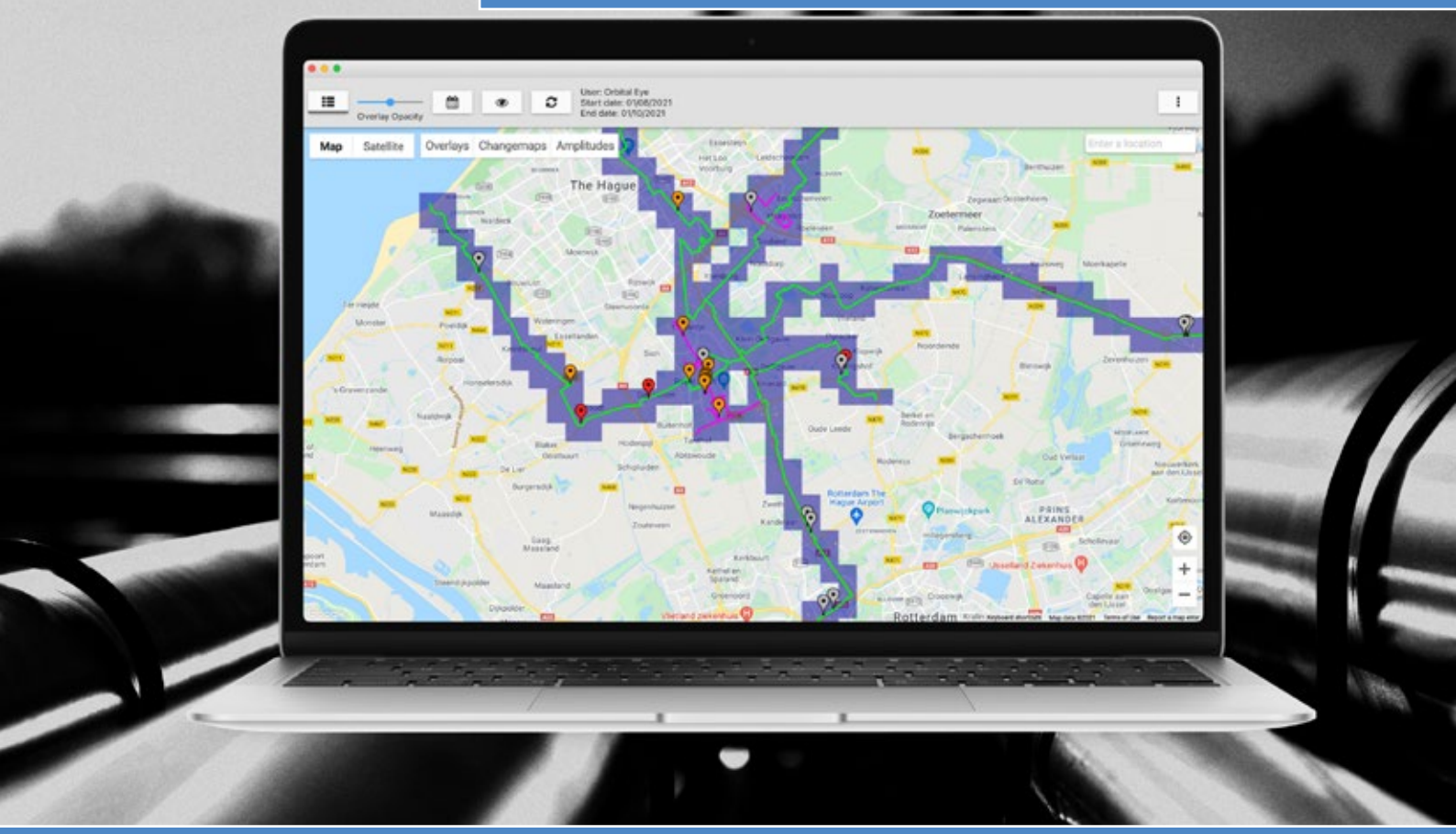
Operational performance validation results for a satellite-based ROW monitoring solution



Alexander Blauw, Dr. Sven van Haver > Orbital Eye

Abstract

For the past decades, helicopter surveys have been the state-of-the-art solution for right-of-way (ROW) monitoring to protect pipelines from third-party-interferences (TPI's). When TPI activities damage a pipeline, it can lead to disastrous events. Therefore, aerial inspection early-warning systems are used to mitigate these risks. Recent developments in Earth observation (EO) technology make satellite-based ROW-monitoring a new contender as a valid TPI early-warning system.

The main drawbacks of aerial platforms relate to weather dependence, unreliability due to a low temporal re-visit rate and subjective reporting by the human observer. Nevertheless, the industry has been holding on to this technology, as it is a proven concept with a perceived high performance and is well-integrated into operations. The satellite-based system, CoSMiC-EYE (Combined-Sar-Multi-spectral-Change detection), has been developed by Orbital to overcome these weaknesses, while operating with a similar false alarm rate and providing an easy-to-use workflow. Presented in an intuitive user-interface, this solution is ready to be integrated into pipeline operators' monitoring capabilities.

In the past two years a number of studies and operational pilots were completed to compare the satellite-based solution to conventional helicopter inspections. In this paper we present and detail our findings of this work which was executed together with a number of European pipeline operators. These results will show, among other valuable insights, that satellite-based ROW-monitoring can in many cases outperform traditional aerial inspections methods in terms of number of relevant detected TPI's, low false alarm rate and illustrate a proven early-warning capability.

When protecting communities, the environment and assets is the main goal of a ROW-monitoring solution, then CoSMiC-EYE is the way forward. EO-solutions no longer behold for the distant future, as the pipeline industry has been assuming. The contrary is true, a satellite-based solution is already here and is ready to become the new industry standard.

1. INTRODUCTION

Pipeline operators are responsible for the safe transmission of their products to protect communities, the environment as well as their own assets. Failures are high impact events, which can cause major damage and casualties. The foremost cause of damage to buried pipelines, together with geohazards and corrosion, is Third Party Interferences (TPI's), such as excavations, construction works or city encroachments.[1] Hence, right-of-way (ROW) monitoring solutions have been introduced over the past decades to mitigate these risks. Basically, any successful ROW-monitoring solution should demonstrate at least the following characteristics:

1. Early warning functionality: (imminent) events should be reported to the pipeline operator as soon as possible.
2. Reliability: all events that pose a risk to the pipeline should be reported to the operators with a low false alarm rate.
3. Ease of use: the technology should be simple to use and suitable to be efficiently integrated in the daily workflow of operators.

The pipeline sector currently uses manned aerial vehicles as their preferred ROW-monitoring solution. A human observer detects anomalies along the pipeline corridor, which are reported to the pipeline operators. In general, human observations from aerial platforms can be very selective resulting in a low false alarm rate, but are also subjective (different observers will report different things) and have a relatively low revisit frequency (due to high costs) causing many TPI's to be left unnoticed, as every location is only visited (bi-)weekly. Furthermore, most aerial platforms such as helicopters or drones, are not reliable under severe weather conditions. As a result, aerial platform-based monitoring solutions are, despite the low false alarm rate, far from optimal due to the low temporal frequency, subjective reporting of events and weather dependence.

Many of the shortcomings of aerial platforms can be addressed by space-born Earth Observation (EO) platforms, which are already numerously present in an orbit around earth. ROW-monitoring using satellites is no longer a mere theoretical concept, but has grown over the past couple of years into a mature and competitive technology. Hence, this technology is now in the final validation stages, preparing for widespread deployment in the pipeline industry in the coming years. This paper will present results for a number of validation campaigns, demonstrating that satellite based TPI monitoring methods are indeed a valid alternative as an early-warning ROW-monitoring solution compared to modern-day helicopter surveys.

In Section 3, the satellite-based monitoring solution CoSMiC-EYE (Combined Sar Multi-spectral Change detection), is introduced, discussing both the technology as well as its operational implementation. Next, a number of validation studies are discussed in Section 3 to show the current performance of satellite-based monitoring and compare the technology to aerial-based solutions. Then, a summary of the main conclusions is given in the discussion of Section 4.

2 BACKGROUND – RIGHT-OF-WAY MONITORING FROM SPACE

The satellite-based monitoring technology discussed in this paper has been developed by Orbital Eye, a company specializing in satellite data analytics. Instead of data products, Orbital Eye offers tailored integrated solutions. In the case of TPI monitoring, pipeline inspectors and managers are provided with a decision support platform to detect, track and manage TPI's along their assets.

One of the challenges for satellite-based monitoring systems is the visual impediment caused by clouds. To overcome this problem, Orbital Eye's monitoring technology is based on Synthetic Aperture Radar (SAR) satellites which are unaffected by cloud cover.[2] The solution makes use of the Sentinel-1 satellite constellation which can observe most locations on Earth up to 120 times a year.[3] The average revisit interval over the whole Earth is six days. This capability to revisit pipeline routes multiple times per month, at a reduced cost compared to traditional aerial surveys, offers the possibility to intercept more potentially hazardous activities. This in turn not only reduces the risks on major incidents, but also helps in avoiding smaller damage that on the long run can result in leaks and fugitive emissions impacting the environment.

At the heart of the Orbital Eye technology is a modified SAR Coherent Change Detection algorithm that compares a stack of co-registered radar images at different capture times. The system acquires radar satellite images along the pipeline routes, and automatically processes and analyses these images to detect anomalies and filter irrelevant changes. For this, both classical image processing and filtering techniques are used, as well as Artificial Intelligence (AI) based methods. These filters have been developed, calibrated and trained using the vast amounts of 'ground truth data' collected during the past five years of pilots and operational campaigns to offer the best possible detection performance. In this way, activities undertaken or caused by humans, which pose the largest threat to the pipeline – such as excavations, illegal settlements and landslides – are retained and reported.

Once anomalies are detected within the pipeline corridor, the software generates an alert which is reported to the client through a notification (see Figure 1). In addition to

Figure 1: Detection and follow-up of a TPI: (a) a detected anomaly is shown on the map interfering with the pipeline corridor, (b) using high-resolution optical data the location of the TPI can be analyzed and (c) a field inspection is done to verify the activity and take mitigating measures when appropriate.

using radar data, the software integrates all relevant geographical information in its servers, which can be displayed in the user interface of the client application. As a result, the pipeline inspectors can obtain a complete overview of all detected TPI's in the ROW, whether reported by radar satellites, aerial platforms, field patrols or wayleave notifications, giving them optimal situational awareness of all activities in and near their ROW.

As the radar alerts do not provide visual interpretable information, optical satellites can be automatically tasked to collect imagery for the locations around the alert. These enable the pipeline operator to classify the alerts from the office and reduces the number of follow-ups in the field. Overall, optical imagery optimizes the workflow and increases the operational efficiency. This additional capability is achieved via a completely machine-to-machine integration with the EarthCache platform of SkyWatch[4], which is a fully automated solution connecting service providers with satellite data repositories. This platform provides the most appropriate high-resolution optical imagery available within the timeframe required, therefore ensuring fast delivery of optical satellite imagery.

The Orbital Eye data service for ROW-monitoring thus offers an early-warning system based on smart data fusion of satellite data and geographical information that enables pipeline inspectors to prioritize and organize their field inspection tasks.

3 HISTORIC AND OPERATIONAL STUDIES

In the past two years, multiple studies were performed to validate the satellite-based solution in an operational environment. During the first year, three transportation networks were monitored for a few months each. When the studies came to an end, the observed interferences were analyzed in an historic study, which highlighted a number of further improvements of the system to make it truly fit to be rolled out as an operational ROW-monitoring solution. These historical studies are discussed in Section 3.1. Next, the improvements were applied and two new studies were performed during the second year. Section 3.2 discusses the results of the study for two transportation pipelines. These results come straight from the field operators and present the latest operational performance of a space-born ROW-monitoring solution. Where available, the satellite-based solution was also measured against helicopter inspections to set a benchmark and compare the performance of both solutions. The comparison to the helicopter inspections is presented in Section 3.3.

3.1 HISTORICAL STUDIES

The first set of studies were performed in The Netherlands and Germany and are summarized in Table 1. One of the studies was conducted with the largest DSO of Germany, Westnetz. The monitored areas covered a variety of land usages from rural regions to dense urban and industrial areas, such as the port of Rotterdam and the Ruhr Area. The combination of these different land uses makes the outcome of these studies representative for most transportation and distribution networks in the world. Hence, the observed performance should be generally applicable to most pipeline operators.

The results discuss all reported activities for the duration of each study that could pose a threat to the pipelines, such as: construction, demolition or ground works. Furthermore, the identified activities were divided into four different categories based on size and duration of the works:

1. Small events are at maximum ~50m2, have at most a few vehicles and little to no heavy equipment on site.
2. Large events are over ~50m2 and are characterized by heavy equipment.
3. Short duration activities are generally lasting up to a couple of days.

	Study 1	Study 2	Study 3
Country	Germany	Germany	Netherlands
Type	Transport	Transport	Transport
Area class	Rural/Urban	Dense Urban	Industrial/Urban/Rural
Pipeline length (km)	170	33	606
Corridor width either side (m)	20	15	15
Duration (months	4	12	3
Anomalies/month	2.8/100km	5.6/100km	2.9/100km

Table 1: Overview of the main characteristics of the three historical studies.

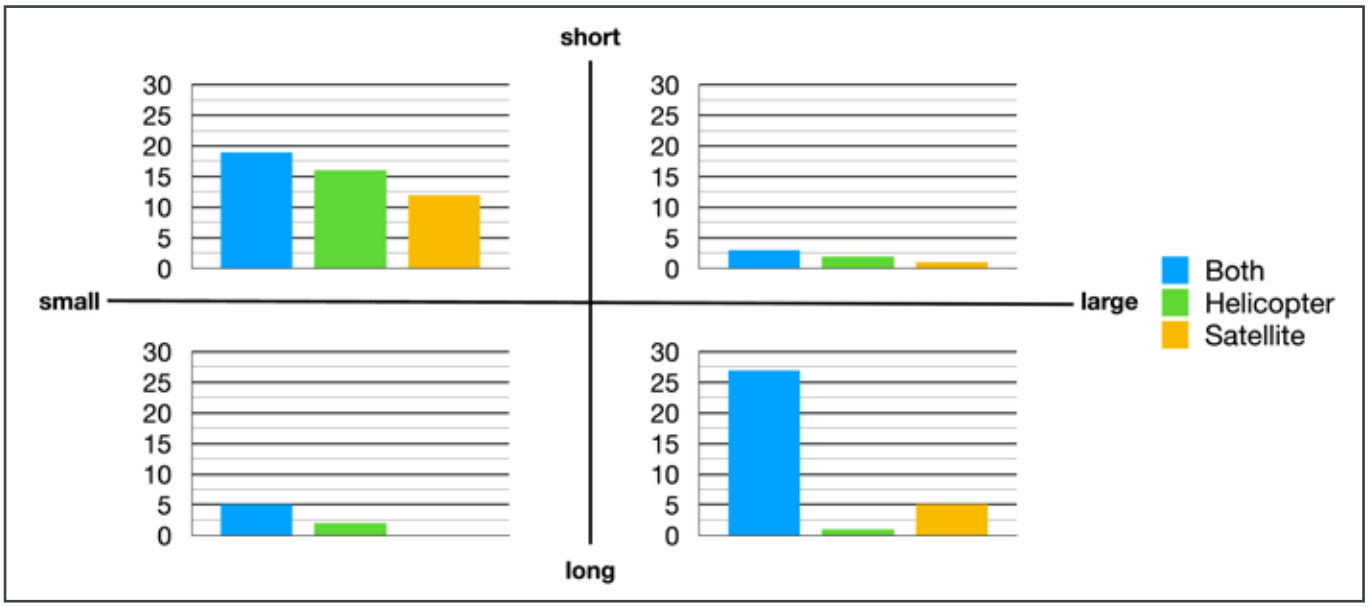


Figure 2: Combined overview of the detected events during three historical studies using the helicopter and satellite, which are divided into four categories based on size and duration of the works.

4. Long duration activities take around a week or longer to complete.

The combined results of all three studies are shown in Figure 2. The number of identified activities is shown for all four categories. Furthermore, the events identified by the helicopter, the satellite or both systems simultaneously are shown separately.

Figure 2 clearly shows that most events taking place within the pipeline corridor consist of small and short-lived events that are shown to have a similar probability of detection for both the helicopter as well as the satellite. Despite the low visit rate (i.e. bi-weekly) the helicopter is able to detect some additional smaller events due to the human observer, who can easily spot small (signs of) works at a low flight altitude. On the other hand, the satellite-based solution has a slightly lower sensitivity, but compensates this by a higher chance of detecting short lived events due to its higher re-visit rate (i.e. at maximum 3 days in Western Europe).

Furthermore, the second category of most common events are the large and long-lived works. Almost all of these events involve ground disturbance. Also, the use of heavy equipment makes this type of event a likely threat to any buried pipeline. The satellite as well as the helicopter are very capable in detecting this type of events. Overall, the satellites-based solution was able to detect more large events compared to the helicopter, which mainly occurred in dense urban areas. This can most likely be explained by the fact that it is more difficult for a human observer to keep track of recent activities within a bigger working site. The observer is basically making spot observations, whereas the satellite-based system is detecting changes (comparing the current state with that of the previous cycle) allowing it to more consistently flag this type of activities. It should be noted here that there is a need for optical imagery to classify activities detected by the satellite. When no optical imagery is available, the number of false alarms can double, which will be discussed in more detail in Section 3.3.

3.2 OPERATIONAL PILOTS

During 2020 two studies were performed in an operational setting for a transportation network. The obtained results reflect the follow-up of all detected interferences by the field operators. An overview of the studies is shown in Table 2.

The TPI's reported during pilot 1 were effectively based on only radar data for a network over 200 kilometers during 2 months. All identified works are shown in Figure 3.

These results are very comparable to the historic studies of Section 3.1. An interesting remark is the ratio of small short-lived events detected by either system. Both systems were able to detected most small short-lived events simultaneously during the historical studies. While the helicopter and satellite detect different events at a similar rate during the first operational pilot, the improvements of the algorithms based on the historical studies have increased the detection rates of the satellite-based solution and proof that the system can compete with the helicopter during an operational pilot.

The second operational pilot took place in the Netherlands and focused on the effect of optical imagery on the false alarm rate. Nine inspection rounds were carried out at a twelve-day interval. All reported locations were visited and classified in the field, which also gave the opportunity to report any missed events. The results are shown in Figure 4 and clearly show the impact of optical data on the false alarm rate. The false alarm rate goes down from 45% to 11%, which is a highly significant improvement and makes the satellite-based ROW-monitoring a suitable operational system.

3.3 SATELLITE VS. HELICOPTER

Four of the studies and pilots presented above, were executed next to an existing helicopter service. The statistics of the helicopter platform were already used to quantify the number of missed events and overlapping reports in comparison to satellite based solution. The same data is used once more to compare the individual performance of the helicopter to the satellite-based solutions with and without additional optical imagery. Figure 5 shows the true and false positive ratio of each monitoring solution tested in the past 2 years.

	Pilot 1	Pilot 2
Country	Netherlands, Belgium	Netherlands
Type	Transport	Transport
Area class	Industrial/Urban/Rural	Industrial/Rural
Size	208 km	130 km
Corridor width either side (m)	30	15
Duration (months	2	3.5
Anomalies/month	10.1/100km	11.1/100km

Table 2: Overview of the main characteristics of the three operational studies.

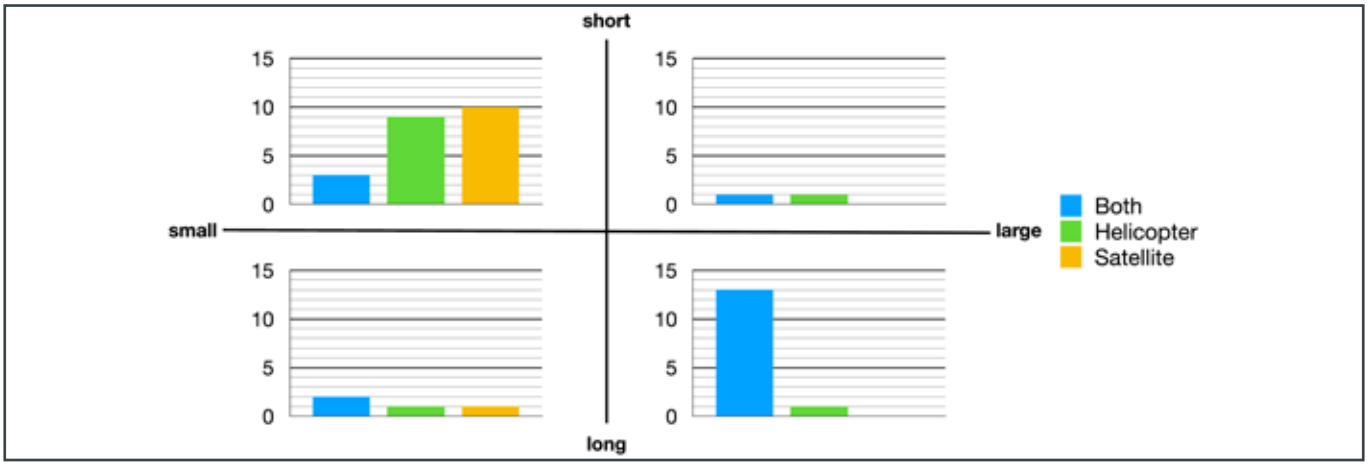


Figure 3: Combined overview of the detected events during first operational study of a transportation pipeline using the helicopter and satellite-based solution, which are divided into four categories based on size and duration of the works.

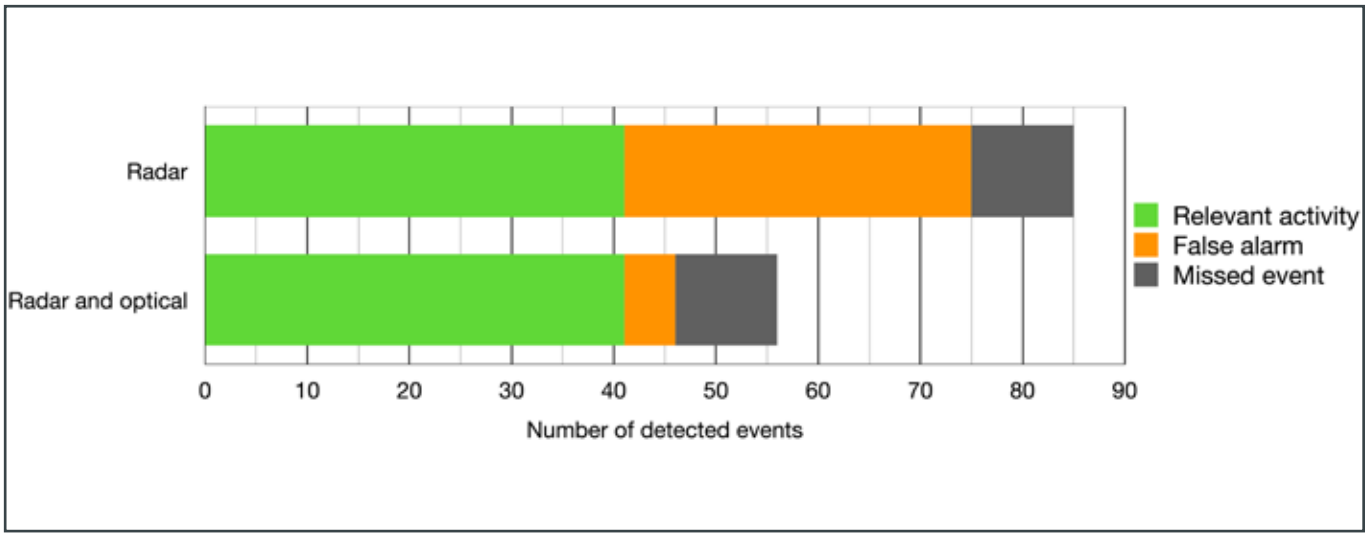


Figure 4: Number of detected events by the satellite during the second operational study of a transportation pipeline. Results for the same pipeline are presented for a system that reports solely based on the radar and a system that also integrates optical data.

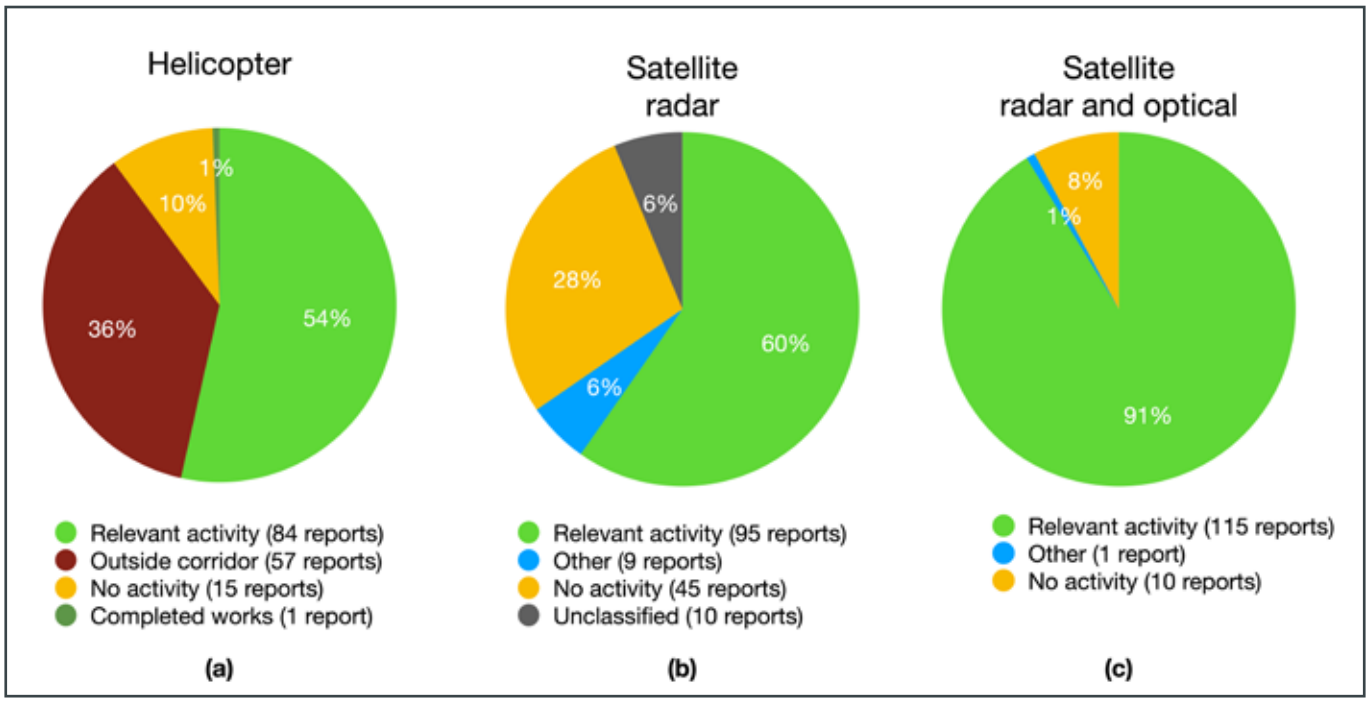


Figure 5: Overview of the true positive and false positive ratio for three monitoring solutions: (a) the helicopter, (b) satellite reporting based on radar and (c) satellite reporting based on radar and optical data.

The results are probably surprising to most pipeline operators, because the helicopter has a true positive ratio only slightly above 50 percent. The main drawback of the helicopter are the reports outside the corridor, which do not pose a threat the monitored pipeline. The false alarms of the satellite solutions are dominated by locations that do not show any relevant activity, the main causes being: agricultural activities, traffic, storage or parking. Comparing Figure 5b and c shows the impact of the optical imagery, which reduces the number of false alarms by 70%, because the sources of false positives, such as traffic or agricultural activities, can be observed in the optical data and prevented. As a result, the satellite solution can significantly outperform the helicopter, when optical data is correctly integrated.

3.4 SUMMARY

A summary of the results from the analysis between the helicopter and the satellite-based solution is shown in Table 3.

	Performance	Comments
Historical Performance Analysis		
Detection of short and small events	Equal performance	- satellite solution observes more frequent - Helicopter is able to detect smaller events.
Detection of long and large events	Satellite performs better	- These events pose the largest threats to damage pipelines.
Operational Performance Analysis		
Detection of short and small events	Equal performance	- Systems report different events within the corridor at equal rates.
Detection of long and large events	Equal performance	- Most important threats detected by both systems.
False alarm rate	Equal or better performance by satellite	- Similar false alarm rate for both systems if satellite only uses radar data - Satellite performance better than the helicopter, if also high-resolution optical data is available
Comparison between satellite and helicopter		
False alarm rate	Satellite performs better	- False alarms of satellite are more difficult to deal with than aerial inspection false alarms (when no optical is available)
Reporting time	Equal performance	- The helicopter and satellite report on average within the next overpass of either system.

Table 3: Overview of the main findings based on the performed historic and operational studies

4 CONCLUSION

The satellite-based solution developed by Orbital Eye is highly competitive compared to modern helicopter surveys when it comes to ROW-monitoring. The satellite technology was validated against the helicopter in numerous studies and pilots over the past two years and showcased equal and sometimes an improved performance over the detections of the aerial platform. As this solution is presented in an easy-to-use interface, both for mobile devices and desktop, it can easily be integrated into pipeline operators' monitoring processes. Three historic studies showed the potential of the satellite solution. Analysis of the large long-lasting events showed that it could even outperform the helicopter, when it came to the detection of large long-lasting works that pose the largest threat to buried pipelines. Just as interesting is the equal performance of both systems when it comes to the detection of small and short-lasting events. One may assume that the helicopter would easily trump a satellite-based system, because the human observer can spot (signs of) smaller works at low flight altitude compared to the lower sensor resolution of satellites. However, the high re-visit rate of the satellite enables these solutions to compete with the human observer even when it came to these small and short-lived working sites.

Furthermore, an additional two pilots were carried out in an operational framework. The results of these pilots reflect the classification of the field operators for all activities reported by the satellite-based solution. When compared to the helicopter, again equal performance was shown for large as well as small events. These studies also highlighted the importance of recent optical imagery for the satellite solution. The optical images are necessary to maintain a low false alarm rate in busy urban areas and allow field operators to classify alerts from the office. Integration of optical data, together with the radar-based detection technology, results in a system that truly offers an operationally viable solution. Finally, the results of all studies were combined to compare the overall statistics of the helicopter to satellite. The true to false positive ratios were computed and the early warning function of both systems was tested. False alarms were reported in 1 out of 3 cases by the helicopter, where the majority of false alarms pertained to activities outside the pipeline corridor. Similarly, 1 in 3 of the locations reported by the satellite solution did not contain a relevant activity and were mainly caused by traffic, storage or agricultural activities. It was proven that this false alarm rate could drop to ~10%, when recent optical imagery was available for all detected events. Therefore, it was illustrated that satellite-based ROW-monitoring solutions can report relevant TPI's with a similar performance as modern

helicopter surveys.

In conclusion, the studies carried out over the past years do not only show the potential of the satellite-based monitoring technology, but also indicate that it can already compete operationally with the helicopter at similar or even lower costs. The strength of the satellite-based system comes from the high visit-rate (i.e. 3 days) and the innovative combination of radar and optical satellites. This combination also makes the system highly reliable as a monitoring service, as the system can always report with basic performance regardless of weather and improves over existing methods when weather allows collection of optical imagery. When protecting communities, the environment and assets are the main goal of a ROW-monitoring solution, then satellite-based technology of is the way forward. EO-solutions no longer behold for the distant future, as the pipeline industry has been assuming. The contrary is true, as a satellite-based solution is already here and can compete to become the industry's latest standard.

References

1. European Gas Pipeline Incident Data Group (EGIG), 10th Report of the European Gas Pipeline Incident Data Group (period 1970 – 2016), Doc. number VA 17.R.0395 (March 2018)
2. Fitch, J. Patrick, Synthetic Aperture Radar, DOI: 10.1007/978-1-4612-3822-5, Springer, New York (1988)
3. European Space Agency (ESA), Sentinel-1 SAR User Guide, (accessed 27/01/2021: https://sentinels.copernicus.eu/web/sentinel/user-guides/sentinel-1-sar)
4. SkyWatch Space Applications Inc., EarthCache, Waterloo, Canada (accessed 27/01/2021: https://www.skywatch.com/earthcache)

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