

Taking Pipeline Integrity Management to a higher level
The PIMS experience of Gasunie

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1. INTRODUCTION

All over the world Pipeline systems have been operated for some decades now. With time passing by, our systems have been subject to deterioration, making Integrity management a top priority more than ever.

N.V Nederlandse Gasunie (Gasunie) is the main gas transportation company in the Netherlands. Gasunie owns \pm 12.000 km of high-pressure (steel) pipeline in the Netherlands and \pm 3.000 km of high-pressure pipeline in Northern Germany, with diameters ranging from 4 to 48 Inch. The Dutch network (as subject of this paper) is split into a high pressure part (HTL, 5600 km, 66-80-100 bar) and a medium pressure part (RTL, 6000 km, 40 bar).

In general, the high pressure network is piggable whereas a significant part of the medium pressure grid is considered to be unpiggable for various reasons. The major part of this grid has been constructed in the period 1960-1980.

1.1. Pipeline Integrity within Gasunie

A reorganisation of Gasunie's technical departments in 2000 resulted in the formation of a dedicated Asset Management department. The need for this new department was a result of a stronger awareness in the public domain, that changed from "don't tell me, show me". Gasunie has always had an outstanding safety performance, but it had to prove the integrity of its pipeline system and therefore Gasunie formulated objectives for demonstrating the quality and good management of its integrity processes:

- Support License to Operate
- Auditable
- More information, more efficiently
- Correlation/Integration data
- Differentiation of Asset measures

Gasunie's intensified focus on registering pipeline integrity would result in a significant increase in the amount of inspection data and processes. The Asset Management department started looking for a software package to enable efficient and reliable data processing and supporting the pipeline integrity management process. For that reason a comprehensive study was performed to identify functionality that had to be supported in the software. The general functionalities are:

- | | |
|---------------------------------------|--------------------------------|
| ▪ Risk Analyses | ▪ Data and document management |
| ▪ Integrity and defect evaluation | ▪ CP modelling and analyses |
| ▪ Advise on repair and lifespan | ▪ Incident registration |
| ▪ Corrosion growth rate distributions | ▪ Economic optimising |

The study resulted in a number of functional specifications that served as input for a market study to identify potential suppliers of Pipeline Integrity Management Systems.

On top of this, some Microbiologically Influenced Corrosion (MIC) was detected on the Dutch high-pressure grid in 1999. This strengthened the opinion of Asset Management that reconsideration of the prevailing policy on pipeline management was required in order to maintain the high standard on risk- and integrity control within Gasunie.

As a result, it was decided that the policy on pipeline management had to change from verification of preventive measures to verification of the actual condition of the pipelines. Up until then Gasunie's policy was to verify pipeline integrity periodically by running an intelligent

pig through one of its high pressure lines on average once every 5 years since the mid 80's, conform regulations. The results of these pig runs confirmed the existing opinion that no corrosion problem existed.

Confronted with these new insights Gasunie developed a new pipeline integrity philosophy resulting in two strategies:

1. Integrity Management: with the aim to comply with prescribed governmental requirements and restrictions of the integrity of the assets and to prioritize, to perform preventive activities and to monitor the actual condition of pipelines
2. Risk Management: with the aim to realize and preserve environmental risk of the pipeline within acceptable (or agreed) level and to prioritize and perform mitigating activities

Consequently the In-Line Inspection (ILI) program was intensified (at the moment 20-25 ILI-runs per year), which of course resulted in a significant increase of the amount of inspection data to analyze. As a result of the intensified focus on pipeline integrity management and increasing data generation, the Asset Management department started an inquiry for an IT solution that would enable efficient and reliable data processing and, above all, support all processes on pipeline integrity management.

1.2. Associated Technology Pipeline Ltd.

In 2001 a Tender was published by NV Nederlandse Gasunie for the purchase of a Pipeline integrity Management System (PIMS). A total of 14 vendors of Integrity management systems submitted there proposal. After a selection round 5 candidates made it to the pre-selection and were invited to demonstrate the offered solution.

Finally it was ATP/ Neftegazsystema (ATP), with a main office in Belarus and a sales office in the UK that offered the best solution; PIMSlider®. PIMSlider® competitive advantage is the integrated way of presenting all available data and the possibility to be able to correlate between the different aspects of pipeline integrity and maintenance. Up to that moment ATP has been focussing mainly on the integrity management solutions for oil companies. The biggest challenge was to adapt the existing, oil based, modules for the gas industry and occasionally also to develop new modules or applications. Next to Gasunie, also Gasunie's former Research Department Gasunie Engineering & Technology, now KEMA Gas Consulting & Services, also made a significant contribution to the implementation and customisation of the solution provided by ATP.

2. PIMS @ N.V. NEDERLANDSE GASUNIE

Incorporating Pipeline Integrity Management is not only implementing software, but also involves changes in the way departments worked so far. Because of the organisational scope the execution of the PIMS implementation required some good planning and availability of resources throughout all departments of the company. At the start of the implementation the work was divided into 3 phases:

1. **Phase 1** primarily consisted of the implementation of "standard" modules and the development of the Quantitative Risk Analyses tool (PSL). In addition, a number of interfaces had to be established between PIMS and the corporate information- and data systems and systems and procedures had to be updated and adjusted. At the same time hardcopy pipeline data had to be converted in a (geo-) database.
2. The majority of the work in **Phase 2** was to solve remaining issues of phase 1 and implement the newly developed Direct Assessment module. Furthermore small adaptations for the other modules were executed and extra effort was put in data and data base issues.
3. During **Phase 3** remaining issues of phase 2 were solved and further adjustments were made to some of the modules and information systems.

In the following paragraphs the 3 phases are discussed divided per phase in a software- and organisational part. At the end of this chapter the lessons learned and international activities of the consortium KEMA Gas Consulting & Services and ATP are mentioned.

2.1. Phase 1: getting started

The first phase of the implementation project in Gasunie's headquarters started in 2001 and was finished in 2005. The implementation process ranged from IT support and technical departments to research. They departments involved worked along ATP staff of approximately 10 to 15 people. During the first Phase part of the ATP work force stayed in the Netherlands for longer periods at the time with the backup of their colleagues in Gomel, Belarus. Because of the different languages, Russian and Dutch, the common language during the project was English and was supported by a Russian-English translator from ATP. This complicating factor in an already complex project proved to be not such a big difficulty as expected. The people from ATP and Gasunie that were involved on a daily basis proved that good cooperation and professionalism can make this challenge a success.

2.1.1. Software

The PIMSlider[®] system consists of a number of modules, of which the heart is formed by Slider4PIMS. The modules cover the whole spectrum of data management (pipeline-, environmental- and incident data), CP system monitoring data, analyses of ILI- and above ground survey data, defect assessments and quantitative risk calculations with consideration of the economics involved. The modules that were already part of ATP's packages included;

Slider4PIMS

This module can be seen as the heart of the system and is used for storage of all pipeline-related data concerning the position of the pipeline, equipment, crossings, operational data, ILI data, maps, photographs, population density along the pipeline etc. It is mainly used for information retrieval. The operator can track the relationships between various figures, as illustrated in Figure 1, and schedule actions accordingly (surveys, repair, maintenance etc).

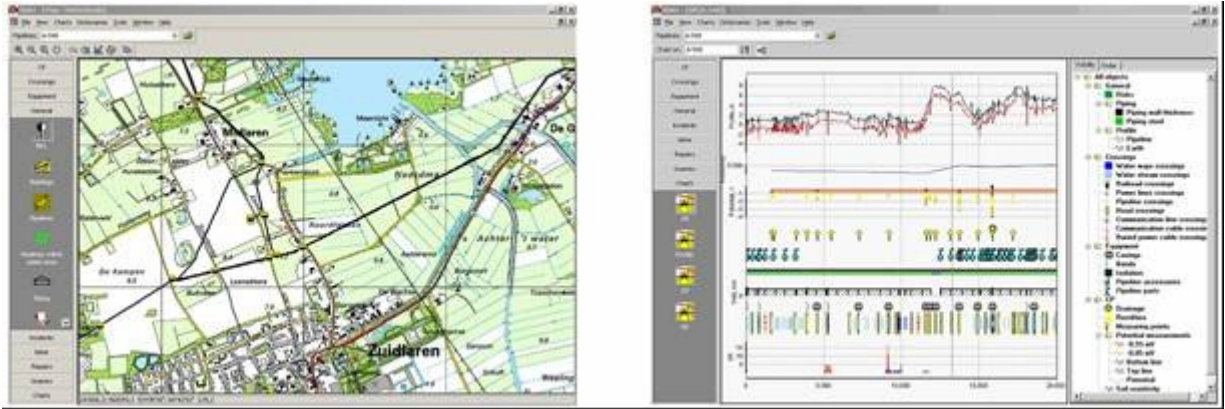


Figure 1: Examples from PIMSlider® ; geographical position of a pipeline (left) and pipeline related and operational data (right).

Risk Expert

This module, the ranking tool for operational pipelines, enables the operator to carry out a relative risk assessment of the pipeline. It is a tool for prioritization of maintenance and inspection programs. This data-based method uses a model that identifies and quantifies the major threats and consequences of pipeline objects and the pipeline environment. The likelihood of all threats is quantified through the use of operational experience, opinions of subject-matter experts or on industry experience. The calculations are performed for all pipeline sections, defined here as parts of the pipeline with unchanged conditions. This allows one to identify local high-risk areas.

Inpipe

Inpipe enables the analysis of any kind of pipeline defect and other features based on the data provided by ILI tools. This involves the linking of the features to map coordinates and an accurate positioning of the in-line data along a 3-dimensional model of the pipeline. The software supports the calculation of the remaining strength of the pipeline using the methods ASME B31G and RSTRENG.

Rehabilitation Expert

This module enables the operator to assess the significance of defects in the pipeline and to define the most appropriate repair program. Defects can be assessed by the use of defect-geometry data as reported by the ILI contractor or by the use of the raw data from the inspection tool (such as individual sensor signals). When more than one ILI has been performed, the same defect can be compared at different stages of its lifetime. This enables the operator to optimize the economics of his inspection and repair program.

CM Expert

This module enables the operator to analyze the effectiveness and the efficiency of an existing CP system. A modelling function supports the CP engineer in the design of the CP system in case of construction or modification of a pipeline. CP Expert utilizes data from Slider. It also allows calculation of the optimum operation mode for CP stations, to ensure reliable and effective protection of the pipeline.

Besides the existing modules Gasunie defined a functional specification for a tool that had to calculate safety distances in accordance with the External Safety policy of the Dutch Government. The Quantitative Risk Analyses tool PipeSafeLite (PSL) was developed by ATP in close cooperation with KEMA's research department; KEMA GCS.

PSL

This module is the core element of the system with respect to risk management of gas transmission pipelines. It is a hazard- and risk-assessment package, which enables automatic quantitative risk calculations to be made at any moment for any pipeline in the Slider database. In addition, it enables the engineer to calculate the effect of risk mitigating measures on an existing pipeline. PSL is based on approaches and assumptions used in PIPESAFE⁷, a risk-assessment model for gas transmission pipelines that was developed by a group of international gas transmission companies.

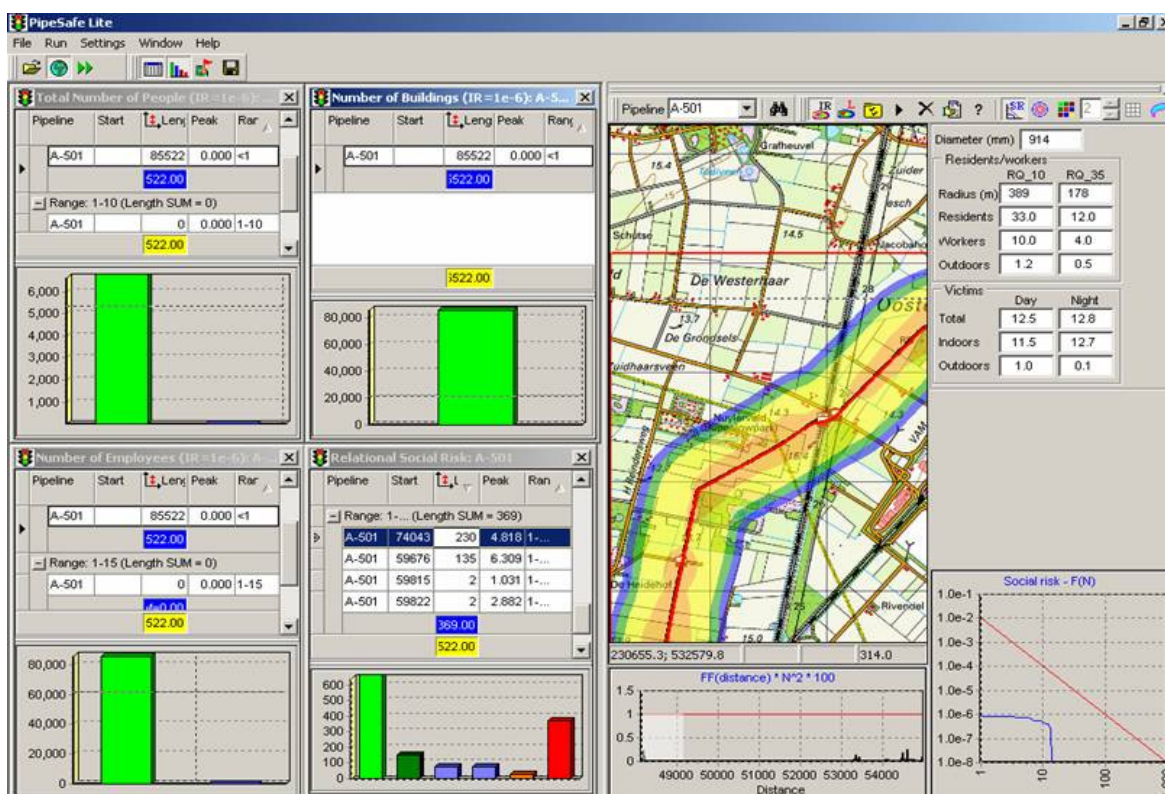


Figure 2: A screenshot of the PSL module; Key Performance Indicators (left) and risk contours and related information (right).

GDLI

The pipeline incidents that have occurred on the Gasunie grid in the past have been stored in the GDLI database. The GDLI module is designed for the analysis and visualization of these incidents.

At the end of the first phase a period of testing was introduced for bug fixing and final acceptance.

2.1.2. Organisational adaptations phase 1

Gasunie knew that the biggest challenge was not the physical installation of the software itself onto computers or servers. The processes and procedures that were necessary to support the "new" way of analyzing and using data needed to be adapted as well. Individual databases that contained all sorts of pipeline information had to be linked to the Slider database and interfaces had to be developed. Old drawings that were only available on paper had to be digitised. ATP developed a method to extract the information based on a scanning technique.

Due to the geographical organisation of Gasunie's field organisation in the regions East, West and South, also the information of the 3 separate drawing chambers had to be integrated in the Slider database. Drawing information, which mostly consisted of digitalised paper drawings, in the Castor data base was being processed and stored in a central data base (GDB). Also maintenance information and data that is stored by every region had to be integrated into the central database. From the GDB an interface was established with the PIMS environment.

Gradually during phase 1 the grown awareness regarding data quality made Gasunie decide to increase the capacity for cleaning, replacing and integrating data. For this activity a special team was formed that had the difficult task to find and convert missing data.

2.2. Phase 2: The first experience

After a period of testing and getting acquainted with the new software and adopting new procedures, a next phase was launched. In this phase 2 additional functionality was specified for different parts of the program and the Direct Assessment module, developed together with KEMA GCS, was added to the PIMS family. The time it took to complete Phase 2 covered most of 2005 and 2006.

Direct Assessment

Because only roughly 50% of the Gasunie system can be inspected by means of Inline inspections, another tool had to be developed that made inspection of primarily the Low pressure grid possible; Direct Assessment module. The module is based on the NACE Recommended Practice for ECDA¹ in combination with Structural Reliability Analysis (SRA). The ECDA process integrates information on the pipeline's physical characteristics including operating history (pre-assessment) with data from multiple field examinations (indirect inspections) and pipe surface evaluations (direct examinations). SRA in combination with Bayesian statistics allows one to quantify the effect of inspections and excavations on the integrity level of the pipeline and, as a consequence, supports the integrity manager in the definition of the required inspection program.²⁻⁶ The increase in reliability that can be achieved by application of SRA and Bayesian statistics, can result in substantial savings on inspection cost.

2.2.1. Organisational adaptations phase 2

In this phase a special focus was given to interfaces for data storage- and retrieving systems like SAP-PM. One of the functions of SAP is storing and processing work orders for the maintenance people in the field. For that reason an interface was created between SAP and PIMS that allowed dig sheet generation in Rehabilitation Expert. Gasunie's Document Information System (DIS) and the Digital Drawing System were connected to PIMS to ensure that all available information can be accessed. Next to that, bug fixing and planned maintenance was carried out by ATP. In order to have access to the most recent information and data an updating mechanism was installed.

As part of rearranging processes and procedures a project called "Eagle" was started in September 2006 to replace the CASTOR drawing system and store data in an object oriented Asset register, instead of storing pipeline data in different systems and different data types. This project is still ongoing and will have a big influence on the efficiency of storing and retrieving data. As a result of the advanced way of presenting pipeline information on a geographical background, also the geographical information had to be updated.

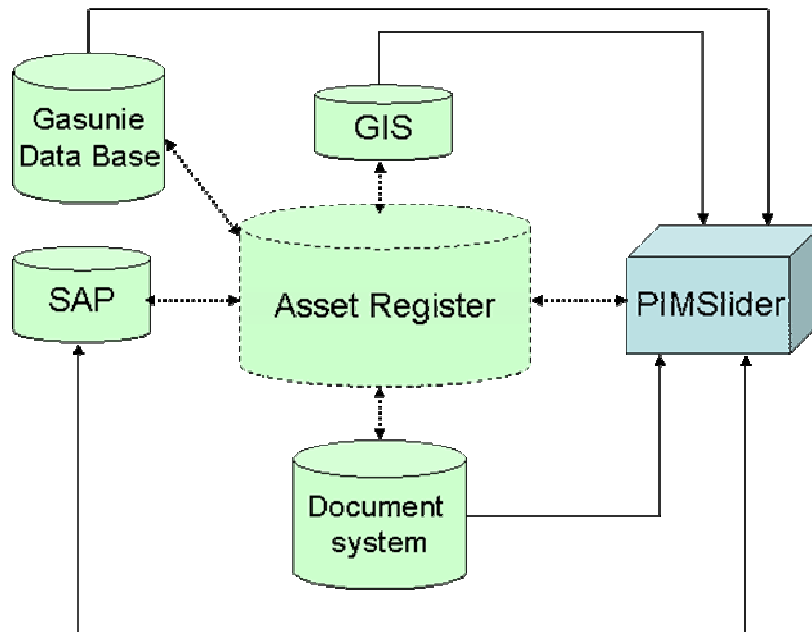


Figure 3: Simplified IT landscape of PIMS at Gasunie and future Asset Register.

2.3. Phase 3: Customizing and adjusting

In 2007/2008 a sabbatical year was introduced in the sense that no major modifications were made to the PIMS system. The idea was to first gain experience with the system so far to be able to define additional requirements based on that experience. During that period a project was carried out to investigate these additional requirements based on the experience of the users. Based on the resulting report an intermediate phase was introduced to make some minor adjustment. The adjustment primarily focussed on the modules Direct Assessment which was still brand new, Inpipe, Rehab and PSL that was updated for the recent changes in the Dutch Law on External Safety that had an impact on the safety calculations.

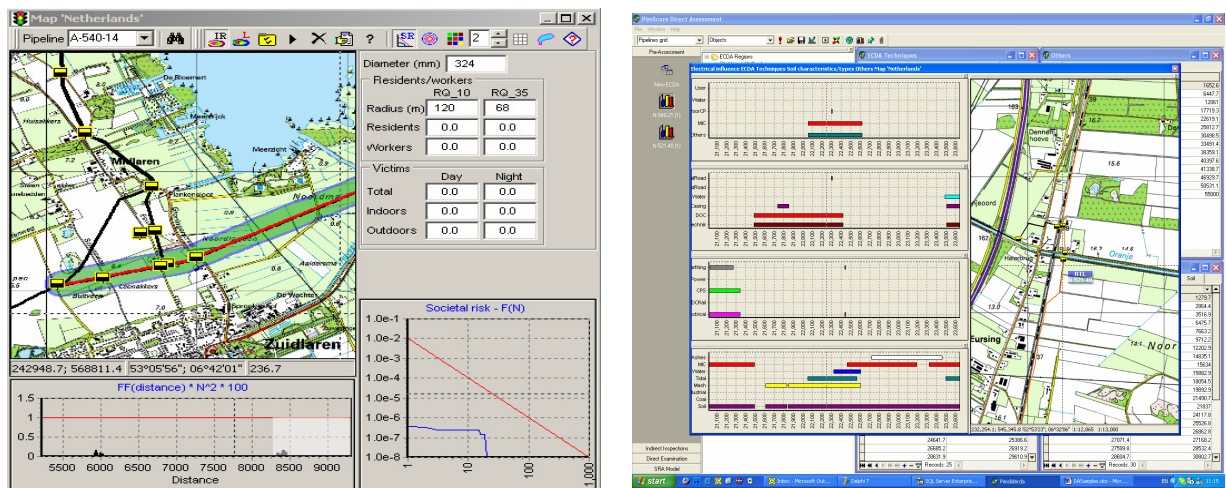


Figure 4: Examples from PipeSafe Lite (left) and Direct Assessment (right).

At this point the company-wide focus on data quality, that was initiated during phase 1, started to show results. Nevertheless this process of data integrity will require continues effort because of expansion and modernising of the system.

3. LESSONS LEARNED

8 years ago Gasunie started the implementation of its Pipeline Integrity Management System. As one of the first companies to engage in this kind of full PIMS implementations, Gasunie (as well as KEMA GCS and ATP) learned a lot about how to handle such implementations, the impact that they can have on the integrity management processes, and which benefits can be derived from the process.

One of the biggest challenges was the quality of data as well as handling all kinds of data types and formats. This resulted in a large amount of extra work, but finally was a big contribution in the information transparency and made it easier to define corrective measures. Gasunie found that some of the data gathered turned out to be not useful for further analyses in PIMS. As a result new data collecting processes were implemented and new data was gathered from that point on. Pipeline integrity triggered a focus on data integrity.

Furthermore implementing a PIMS system, as has been done by Gasunie, involves every department of a company and therefore it is crucial to have management support at all levels. The benefits that are clearly derived from this intensive process of implementing a PIMS:

- Data transparency
- More efficiency in Data collection
- Awareness of importance of pipeline integrity across all departments, “not the work of just Asset management”
- Incentive to upgrade and reorganise GEO information systems and Integrity processes in general
- Prove of being a prudent Operator and support for the License to Operate
- More efficient storing and fully integrated analysis of all available data
- General access to data via central database

3.1.1. Future work Gasunie

The work that will be ongoing is the updating of database with good quality data and information. After phase 2 more and more people in different departments started working with (specific modules in) PIMS. As more people start to work with the expert modules new ways of using the tools and additional functionality will start to come to surface, making PIMSlider® even more valuable as an integrity management tool.

During the implementation of PIMSlider® in Gasunie some useful changes were announced to upgrade the process of gathering and analysing Cathodic Protection (CP) data. Therefore the years to come will be used to specify and fine-tune the new CP processes. Eventually Gasunie has to decide how this information can be incorporated in the current Integrity Management system.

At the moment KEMA GCS and the Netherlands Ministry of Housing, Spatial Planning and the Environment are developing a risk tool based on PSL for local municipalities. In future, this tool will help the local government with planning issues involving gas pipelines.

Next to Pipelines, most gas transportation networks also contain installations for pressure reduction, metering or compression. In order to create a total picture of all assets, KEMA GCS and ATP started a study to identify the possibilities for Station Integrity Management System (SIMS).

3.2. PIMSlider® going International

Next to the ongoing perfection of the PIMS processes, Gasunie together with ATP decided to market this solution to other colleague gas transportation company's. The fact that the different modules of PIMSlider® can be directly linked with for example the ASME B31.8S¹¹ is an advantage in terms of relating the PIMS process to a world wide accepted Integrity Management framework.

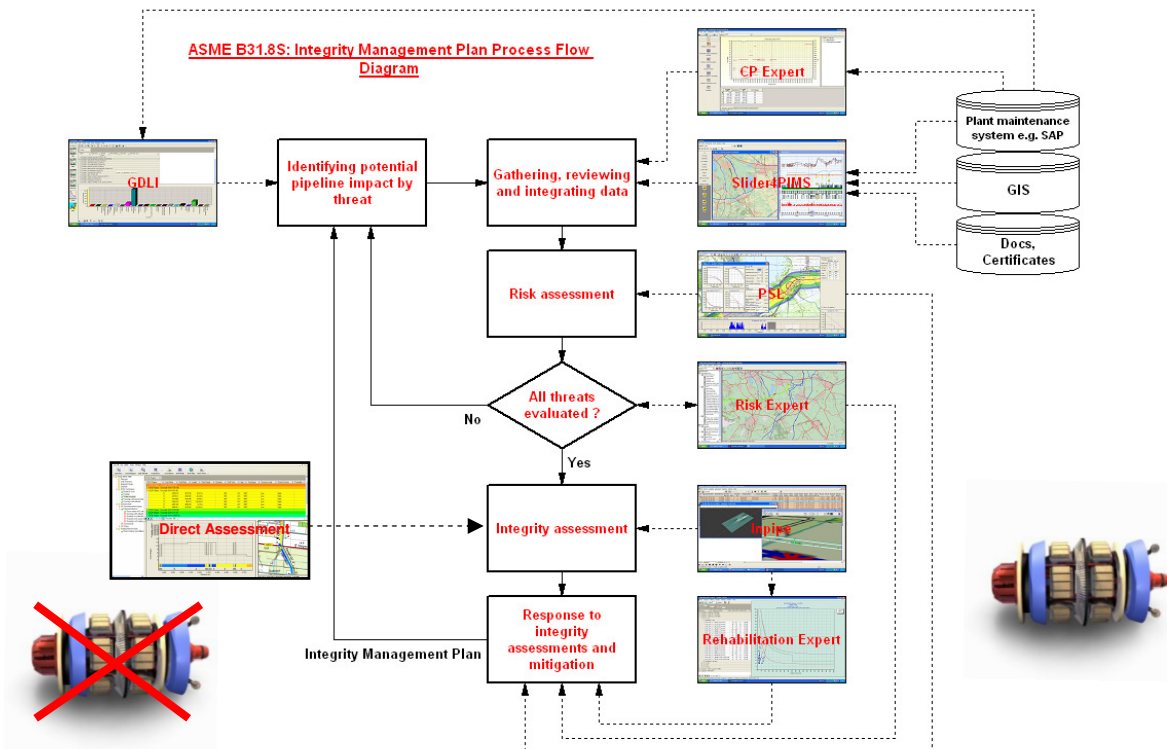


Figure 5: PIMSlider® modules in relation to ASME B31.8S.

Therefore KEMA GCS and ATP have set up a consortium that successfully markets this concept to third party clients all over the world.

One of today's biggest ambassadors of PIMSlider® is SASOL Gas who recognised the benefits of Gasunie's methodology of Pipeline Integrity management. The implementation project in South Africa started in 2004 and comprises all available modules except for GDLI and Direct Assessment. Other companies that adopted the Gasunie approach are Geoplin Plinovodi (Slovenia), RWE Transgas (Czech Republic) and PTT (Thailand). There are also two publications of PiMSlider® implementation project available in the public domain, being SASOL Gas⁹ (South Africa) and Geoplin Plinovodi¹⁰ (Slovenia).

3.3. Continuous improvement

In a time that technology and standards are rapidly changing, At the moment ATP is developing the second version of its PIMSlider® system. In this next version the experiences of the past years are incorporated and new technologies are added. Some of the developments are adding mitigating action in the Threat & Mitigation Expert-module (successor Risk Expert) for better priority setting, and an improved and comprehensive viewer function for GIS information. This module also supports economic decision making for, repair activities, re-inspection intervals and effective implementation of protective measures (ILI, CP, patrolling, etc.).

In the beginning of 2009 a pilot project is carried out to extend the PIMSlider-family with a module specifically covering the requirements for off shore pipelines.

In short, PiMSlider® is a simple intuitive and easy scalable tool to store, display and update pipeline data, combined with intelligent search utilities to locate specific information about the pipeline. Above all it is more than only IT: it is a real philosophy involving all activities within a gastransmission company.

4. CONCLUSIONS

The changing condition of our assets has driven the need for better data and analyses. Gasunie identified this increasing focus on Integrity management processes and systems. The process of preparation, selection and implementation of a Pipeline Integrity Management System within Gasunie started in 2001 and so far has been proven very useful.

The objectives that Gasunie's Asset Management Department formulated in terms of software supporting Integrity management are as follows;

- Support License to Operate; transparency of pipeline information and expert tools to analyse those data enables a company to present all relevant information at all times and link directly to corrective actions whenever needed.
- Auditable; the increased awareness of data and integrity procedures combined with the centralised way of storing data gives clear insight in the way Gasunie operates and is therefore increasingly transparent for verification.
- More information, more efficiently; the amount of data has dramatically increased in the past few years, giving a company more useful information. Combined with high standard storing and retrieving possibilities, PIMSlider® makes finding information highly efficient.
- Correlation/Integration of data; the analyses and results generated by Gasunie Experts in the different expert modules can be integrated and viewed on screen by means of the module Slider4Pims. Therefore it has become much easier to correlate data of different expertises and make cross references that could not have been performed before.
- Differentiation of Asset measures; At this moment Gasunie is in a better position to determine what kind of measures can be taken best in terms of pipeline maintenance. Nevertheless, at this moment it is not (yet) possible to really differentiate between different types of measures based only on PIMSlider®.

Along the way we encountered unexpected difficulties and challenges. Nevertheless, Gasunie has decided that the system plays an important role in Gasunie's mission to maintain a high standard of pipeline integrity in the future and operate its pipeline system in a safe and cost effective manner.

4.1. Acknowledgement

Without being exhaustive KEMA GCS would like to thank our colleagues at Gasunie and ATP/Neftegazsystema for their, still ongoing, contribution and support to the process of developing PIMS.

REFERENCES

1. NACE Standard Recommended Practice RP0502-2002 (2002). Pipeline External Corrosion Direct Assessment Methodology, Houston, Texas.
2. Francis, A., Edwards, A.M., Espiner, R.J. and Senior, G. (1999). Applying Structural Reliability Methods to Ageing Pipelines, Paper C571/011/99, IMechE Conference on Ageing Pipelines, Newcastle, UK.
3. Francis, A. and McCallum, M.A. (2003). Integrity Management Using Direct Assessment and Structural Reliability Analysis, Workshop at Gasunie Research, Groningen, The Netherlands.
4. Andrew Francis & Associates Limited (2004). A Robust Methodology for External Corrosion Direct Assessment, Report AFAA-R0003-04.
5. Andrew Francis & Associates Limited (2004). A Robust Methodology for External Corrosion Direct Assessment-Supplement, Report AFAA-R0004-04.
6. Francis A., Harris, J., McCallum, M.A., McQueen, M., Sansom, A. and Ward, C.R. (2005). Structural Reliability Analysis for ECDA, Prepared for Gas Research Institute, GRI-04/0093.2.
7. Acton M.R., Baldwin P.J., Baldwin T.R., Jager E.E.R., (1998), *The Development of the PIPESAFE Risk Assessment Package for Gas Transmission Pipelines*, Proceedings of the International Pipeline Conference, ASME International, Book no. G1075A.
8. Acton M.R., Baldwin P.J., Baldwin T.R., Jager E.E.R., (2002), *Recent Developments in the Design and Application of the PIPESAFE Risk Assessment Package for Gas Transmission Pipelines*, Proceedings of the International Pipeline Conference, IPC02-27196, Calgary, Canada.
9. Bos, R. (2005), Journal of Pipeline Integrity, "The PIMS Implementation Program for Sasol's Gas Operations", Quarter 1
10. Kutrowski, K., Bos, R., Van Elteren, R., Glover A., Skrbec, B., (2007), Journal of Pipeline Integrity, "Implementation of a pipeline-integrity management system for Geoplin Plinovodi, Slovenia", September
11. ASME B31.8S (2004). Managing System Integrity of Gas Pipelines, Supplement to ASME B31.8.