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E-MAGAZINE

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EEFDE LOCK AND EEFDE LOCK AS A LEARNING ENVIRONMENT

PROJECT: THE ZEELAND BRIDGE

5 years of Fieldlab CAMINO

Photo: WCM Summer School Reindert Hoeksema, Jenne Hoekstra

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Made possible by the partners of WCM & CAMINO

5 years of Fieldlab CAMINO

CAMINO celebrates a wonderful milestone this year: its fifth birthday. Yet how did this Fieldlab come about? For the first steps we need to go back as far as 2008, the year in which World Class Maintenance was founded. In the early years, the emphasis was on military aviation (maintenance valley). When the Dutch Ministry of Defence acquired its new fighter jet (F-35 Lightning II), it decided it also wanted to apply Smart Maintenance.

Although this was only thirteen years ago, many people thought we were insane. What possible benefits could smart maintenance bring? It was seen mostly as an expensive project. Luckily there were also plenty of people who did believe in the future of Smart Maintenance. Moreover, the Internet of Things was growing and an increasing number of sensors, data analysis tools and algorithms were being launched on the market. We quickly expanded our operations to include the processing industry. The innovations we implemented here proved to be a success.

Slowly but surely we were able to convince more and more organisations of the added value of Smart Maintenance for their operating process and sustainability. We asked ourselves where else we could apply these same innovations. And that is how the infra sector came into our sights, a sector that spends many billions of euros a year on maintenance. In 2016 we set up the Fieldlab CAMINO with the aim of making maintenance in the infra sector 100% predictable.

Once again our ideas were contrary to prevailing opinion. The first tipping point was a failure at Merwede bridge, leading to it suddenly being closed to heavy goods vehicles. More and more people started to ask themselves how it was possible that this type of infrastructure was not monitored. Things really started to come together after this. Universities conducted research into smart asset maintenance and asset owners such as the Ministry of Infrastructure and Water Management, water boards and municipalities wanted to improve the way they manage their maintenance. CAMINO started to gain momentum as a result of all this.

Now, five years on, CAMINO has demonstrated not only that smart maintenance is possible but - more importantly - that it delivers added value. Thanks to Smart Maintenance, assets are available more often, maintenance can be carried out more cheaply and only at those times when it is necessary. Components also last longer. This longer lifespan is a major step towards greater sustainability in the infra sector.

It is thanks to the efforts of the initial group of enthusiasts that we have been able to place Smart Maintenance firmly on the map. Yet it is thanks to the hard work of a large number of people who have joined us over the years that we now stand where we are. In five years we have shown that our innovations work in practice. The task of further rolling this out now lies with the asset owners. Yet one thing is certain: Smart Maintenance is the future.

I would like to thank everyone involved for their hard work, their faith in our goal and their smart ideas. This magazine shows you what we have been doing for the past five years and we hope it will inspire you for the future.

Happy reading!

Lex Besselink
Chair of the Board of World Class Maintenance

5 changes in 5 years of CAMINO

The start of CAMINO: it seems ages ago and yet feels like yesterday. In January 2016 we took the first steps towards setting up this Fieldlab. Back then we could never have imagined where we would be today. These five things have changed in five years of CAMINO.

#1 From curious onlookers to engaged partners

In January 2016, asset owners met for the first time to talk about maintenance and digitisation in their respective organisations. Together with six parties, we brainstormed on what could be done better, smarter and more effectively in the infra sector. Among the first interested parties were Vechtstromen water board, Sitech, the Ministry of Infrastructure and Water Management and the municipalities of Enschede and Almelo. Together they decided to throw their weight behind the initiative and create something new in the shape of Fieldlab CAMINO. Since then the group has grown enormously but these organisations remain loyal partners of our Fieldlab.

#2 From subsidies to self-financing

Just before CAMINO was founded, Fieldlab CAMPIONE, which focuses on predictive maintenance in the processing industry, had received EUR13 million in subsidies. The idea was to adopt a similar approach with CAMINO but for water, rail and electricity infrastructure. As time progressed, however, it became clear that it would not be possible to submit a subsidy application. The end of CAMINO? No, nothing of the sort, because the water domain in particular was displaying a great deal of interest in smart maintenance. There turned out to be enough ambition for researching this to find other sources of financing. Following a start-up phase in 2017, the first field lab was initiated in 2018.

#3 From vision to experience

The start of the first field lab was an important milestone for CAMINO. Where we had previously only been able to share our vision - 100% predictive maintenance in the infra sector - now we had a tangible example. This aroused the interest of a growing number of parties. In 2017 just twelve parties had signed up, but that number grew to 40 in 2018. To date that remains the biggest growth spurt Fieldlab has ever experienced. As of 2021 we have 50 parties on the books.

#4 From ‘will it come to anything?’ to ‘why aren’t you doing anything with it?’

Minister Van Nieuwenhuizen expressed her support for CAMINO in 2018. She announced her firm commitment to Smart Maintenance on behalf of the Ministry of Infrastructure and Water Management. From that moment, talks with interested parties changed from a hesitant ‘should we really do this?’ to a resounding ‘this is the future!’. That served to reinforce CAMINO’s position. If the government supports it, why would an organisation not yet be doing anything with it?

#5 From an experiment to structural approach

Nine different field labs are already up and running and eight are in preparation. We experiment with smart maintenance in all of these field labs. The aim is to implement these experiments quickly at national level. This is the reason behind FME and World Class Maintenance sending a letter to ‘informateur’ Herman Tjeenk Willink (the politician charged with investigating the formation of a government cabinet). The letter sets out our plans for structurally tackling infrastructure maintenance in a smarter manner. Of the billions of euros the Ministry of Infrastructure and Water Management requires for additional maintenance, 10% needs to be allocated to smart maintenance. Then we will be able to realise our ambition of 100% predictive maintenance in the infra sector.

The Zeeland bridge

Applying structural condition monitoring

What do a national monument and predictive maintenance have in common? In the case of the Zeeland bridge everything. This imposing steel structure is not just an important link for traffic, in 2015 it was also declared a national monument. At around this time, questions started to be asked at the province of Zeeland: so far there haven't been any impactful failures, but what if one occurs? The repercussions could be enormous. Together with infra asset manager Istimewa and HZ University of Applied Sciences, the province decided to examine what predictive maintenance could mean for them. As part of this process they signed up to CAMINO in 2019.

"The ultimate goal is to make maintenance on the Zeeland bridge completely predictable. Yet before we reach that stage, we have plenty of smaller goals we want to achieve first." Those are the words of Pieter van 't Westeinde, Maintenance Manager at Istimewa. He explains how the ambitions of the field lab were defined: "Istimewa has carried out maintenance on the assets of the province of Zeeland for the past 40 years. Traditionally we conduct inspections at agreed intervals. For the Zeeland bridge we now want to investigate the options for condition monitoring. Yet this is an enormously broad topic. To break these goals down into a manageable size, we've selected our focus points in three steps."
Reindert Hoeksema, Maintenance Engineer at Istimewa, sets out the steps: "We started by listing the components that make up the bridge. Next we conducted a risk analysis of each individual component. Which component experiences the most failures? What are the consequences of a failure? And what is it interesting to predict? It turned out that we had multiple failures caused by dirty cameras, but it's not interesting to monitor that. If, however, something goes wrong with the bridge's primary movement mechanism - for example in the electric motor or gearboxes - the repercussions are huge. That's why we opted to focus on those components in the field lab."
Pieter continues: "The next question is what type of data you want to collect. You could of course plaster the bridge with sensors, but you also need to be able to interpret all the data you collect. It's better to do this step by step. By starting with a narrow area, it's much easier to work out where a failure originates. This modus operandi is ideal for gaining experience of the functioning of sensors and data models.

Structured innovation

To get the step towards predictive maintenance right the first time, World Class Maintenance was brought in to participate in the project. Imco Flipse, Theme manager for wet infrastructure at the province of Zeeland: "World Class Maintenance, and in this case CAMINO, already possesses experience of condition monitoring in other field labs. Over time it has developed a structure that is aligned with this type of innovation. It's now using this at our organisation to ensure the process is on the right track. The multiple options offered by innovation mean that it's easy to become disorientated, but CAMINO helps us to filter that out."
At the same time, innovation also means you need to be open to new ideas. Reindert: "Even though CAMINO has supervised many such projects, we're given every freedom in the decisions we make. For instance about the sensors we use. CAMINO knows the suppliers it's worked with before. Yet we can still conduct our own research and decide what we want to use. This free-form thinking is an important part of the process to me. We have a structure, but within that there's more than enough room for new ideas."

Positive team spirit

Innovating in a field lab means working together with other parties. And that is precisely what the Zeeland bridge team appreciates. Reindert: "I notice that we have access to a great deal of in-house expertise thanks to collaborating with different parties. These people know what they're talking about. It's not just that though: most of all we enjoy being involved in the project. That's what makes the team spirit so positive. It not only creates a pleasant working atmosphere but also ensures that we really want to achieve this together. Everyone goes about it seriously and ambitiously. I'm convinced this will help us to accomplish our goals."

Lessons learned

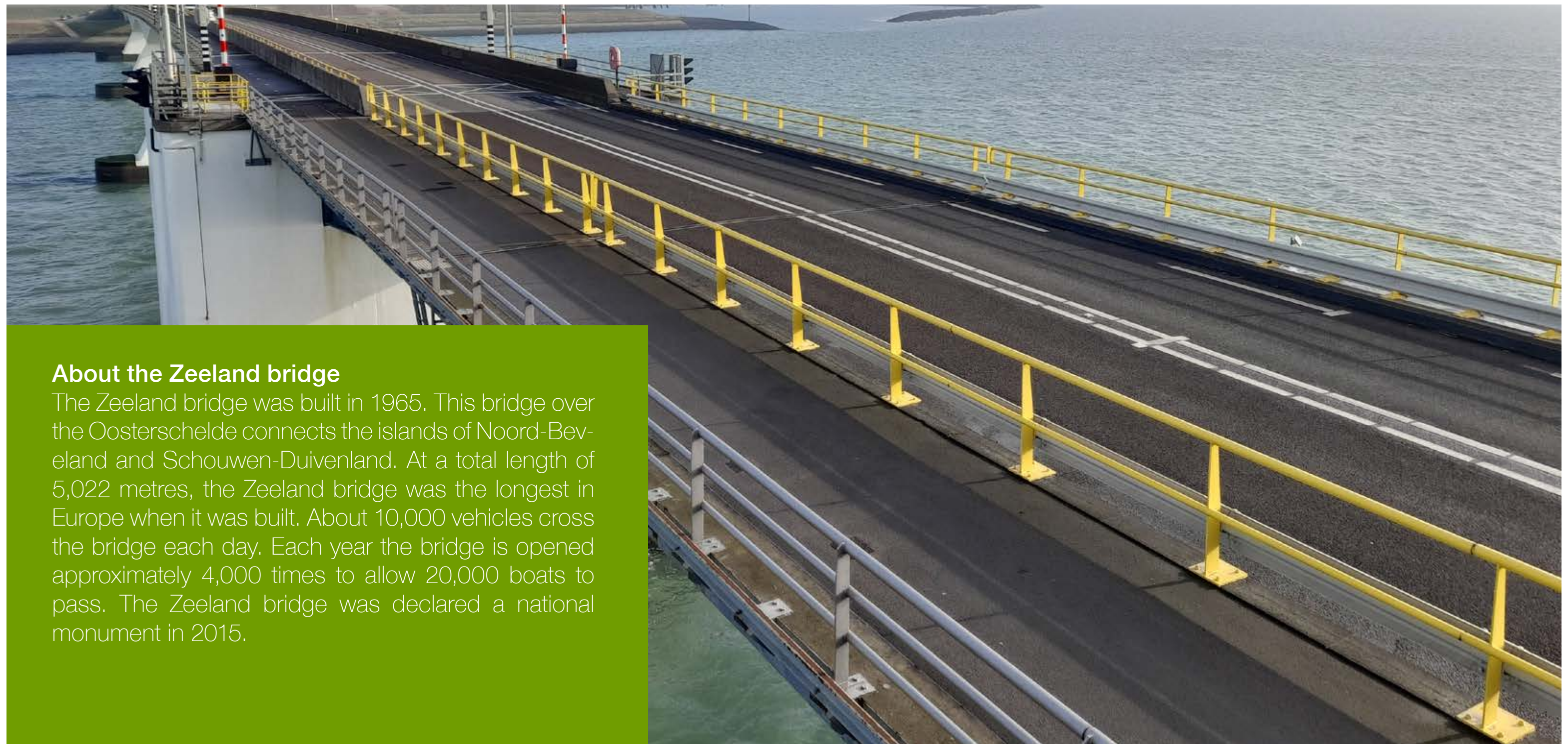
Although no-one can predict the outcome of a field lab, one thing is certain: you always learn something. This starts when you examine how you do things now. Imco: "The province has applied the same maintenance strategy to the Zeeland bridge for many years. Yet the risk analysis showed that the strategy's priorities aren't always logical. For example, we have the railing painted every year but devote little attention to some critical components. All this while the Zeeland bridge is extremely important to the province: to the mobility of residents but also to tourism. A major failure could potentially cause a huge amount of damage."
And in terms of the approach, the Zeeland bridge team has a lesson it wants to pass on to others. Pieter: "We approach this project step by step. That structure is extremely important. You can throw a few smart people together but if they're not given any guidance, you won't achieve any results. CAMINO really stands for adhering to a process. At each step we analyse what it yields. This helps to keep it manageable. Including in terms of investment. On a relatively small budget we can gain an enormous amount of experience."

The parties involved

- HZ University of Applied Sciences: knowledge and research institute
- Istimewa: infra asset manager and maintenance expert
- Province of Zeeland: infra asset owner and initiator
- World Class Maintenance: project supervisor and driver

Istimewa and predictive maintenance

Istimewa Elektro designs, manages and maintains systems in the infra and water sectors. Although it had previously conducted projects in which predictive maintenance played a role, the Zeeland bridge is its first research project in this field. In the field lab Istimewa combines the knowledge of experts with its many years of experience in maintaining the bridge. This practical and theoretical mindset is typical of this company that started out as a family business in the province of Zeeland.



About the Zeeland bridge

The Zeeland bridge was built in 1965. This bridge over the Oosterschelde connects the islands of Noord-Beveland and Schouwen-Duivenland. At a total length of 5,022 metres, the Zeeland bridge was the longest in Europe when it was built. About 10,000 vehicles cross the bridge each day. Each year the bridge is opened approximately 4,000 times to allow 20,000 boats to pass. The Zeeland bridge was declared a national monument in 2015.

The Zeeland bridge field lab starts to collect data in the second half of 2021. Following the preparatory stage, this is the first tangible step towards condition monitoring.

When is a field lab a success? The experience of RTC Almelo

Optimising the Real-Time Control system in Almelo that regulates control of the urban drainage system when a large amount of rain is forecast was the first step towards creating a simulation model and machine learning system for efficient urban drainage management, policy advisor Marcel Roordink tells us. In this interview we explore the question: How far can you go in digitising urban drainage management?

In order to comply with the 2001 baseline policy on urban drainage, a RTC system was installed in Almelo and sensors placed in catchments at various locations throughout the urban drainage system. This is now yielding multiple benefits according to Marcel Roordink. He has worked at the municipality of Almelo since 2005 and is responsible for the increasingly far-reaching digital strategy for obtaining insight into the system and improving its use and management. Now that the Fieldlab CAMINO RTC Almelo project has been up and running for two years, we decided to interview him to hear about the initial results.

RIONED: As an introduction, can you give us a general idea of how you set to work?
Marcel Roordink: Improving control of Almelo's urban drainage system has been a major goal for many years. We're a small and stable team that's responsible for all water-related matters in the municipality, and we're curious and continuously driven to improve things.

We've therefore had sensors installed in various locations for some time now. These sensors tell us which sections of the drainage system fill up (too much) when it rains so that we can respond more quickly by pumping in specific locations or by retaining water. As a result of this we can make sure the water takes the best-possible route as it flows through the drainage system towards the water purification facilities and, for instance, prevent overflows or flooded streets as far as possible.

The RTC system works well but you can always improve things. A large part of it is experience but maybe things can be done in a smarter way. Manual tasks and human estimates are also involved, while a computer might well be able to make smarter decisions. A few years ago this prompted the municipality of Almelo and Vechtstromen water board to identify some wonderful opportunities for testing out new technologies in urban drainage and decide to initiate the CAMINO project. Together with seven organisations, using Artificial Intelligence we collaborate within this project to optimise water flows, maintenance and energy consumption based on logarithms. We use a simulation model of the system to this end.

To start with the basics, you can only create a model that works properly if your data is in order. How do you accomplish this?
Marcel: That's right, good data is essential and it's really a question of consistently and continuously examining the individual sections of the urban drainage system and the sensor data. In rotation you extract individual data points (or one part of the urban area) following a good sharp shower. And then you take a good look at it: check if the data is correct, remove any errors, calibrate and validate it. Bit by bit you improve the data and your insight into the urban area's system. And you do this each time because you need reliable data to be able to create a simulation. The model needs to correspond to reality. And not forgetting that it's also important for the management data to be well organised for a good model.

Who works on the simulation model?
Marcel: We approached a variety of partners for this and sat down with them to develop a high-quality model. These include Benchmark Electronics, a US software company based here in Almelo, Deltares (in relation to using its Sobek calculation software), Nelen & Schuurmans (in relation to constructing the models), Inter Act (for the telemetrics), World Class Maintenance (due to its expertise on predictive maintenance) and Vechtstromen water board.

How do you select your data sources? And what problems did you encounter when you started to collect data?
Marcel: Our simulation model requires many data sources that are properly safeguarded in the municipality. And only data sources with sound operating processes that work well. This might include management data, structure data, hydraulic data and also data on connected hard surfaces. Just as you think everything's sorted you suddenly realise, for example, that an overflow well containing a wall is recorded in a control system in a specific way that turns out to deviate slightly from reality. For a manager the precise specifications of the wall (height/width) or how oblique the angle is are irrelevant. Yet these things are important when it comes to calculations. Where is the wall located, is it for one or two pipes and which water flows against it etc.? We needed to solve all of these issues, step by step. The details need to be correct.

That's when we came up with compartmentalisation, with the aid of the GWSW (urban water data dictionary) standards. This enabled us to describe everything properly in terms of how it all fits together hydraulically. Problem solved, you think. Only the Antea GBI management package wasn't yet totally geared to this. So it took us some time to get it completely right. The great thing was that Antea was already in talks with you, RIONED Foundation, on incorporating the standards. It became actively involved in our project, brainstorming and testing in order to get everything right for its software. As a result, its system will soon be suitable for modelling in accordance with the GWSW standards.

The other wonderful thing is of course that thanks to the GWSW standards what we're developing here in Almelo can be used elsewhere. In principle the software will work with any drainage data set based on the standards.

The model can be filled using the data. When will the model be ready for use?
Marcel: We're now in the final phase of the project. Things are moving quickly. We're still calibrating and validating the data. For instance, by selecting a good sharp shower, one that really happened, not too much and not too little, just a good shower, and simulating that in the model and then comparing it to what we see and measure in practice. We've also reached this final phase by connecting the Deltares Sobek system to our control system. This was new for Deltares as well and now we know for certain that the same control rules are used in both practice and theory. It took us a little bit of extra development time but this has now been incorporated into the Sobek manual with Almelo as an example. That's great. I would now dare to say we want to complete the project in the summer of 2021. Then we'll have significantly improved the RTC system once again. After that we'll need to decide whether to develop the machine learning tool further so that we can perhaps use it again in the future. We're still seeking new partners for this.

The data and RTC model connection were required to come up with a self-learning system using artificial intelligence. That system can take control in the event of heavy rainfall. How does this work?
Marcel: We opted for an approach in which we don't allow the system to learn continuously but periodically.
Not in practice but in a simulation model. In doing so we have everything under control and can calculate a wide range of different situations and also extremes, without being dependent on what happens in the actual system or what the weather does. However, this means that the simulation model needs to correspond exactly to reality. The calibration and validation I mentioned earlier are essential parts of the process.

We've chosen to apply an algorithm to the model that learns based on feedback, reward and punishment. In the model a large number of changes to control parameters are tested and analysed in terms of the effects. If they were correct, the system is awarded bonus points. If they were wrong, the algorithm will reward less easily from then on. It's important to think hard about what you want to reward so that the computer knows what it needs to monitor. If you don't do that properly, things can go badly wrong.

As we were unable to investigate everything simultaneously, we initially focused on water management, which meant less of a focus on optimising energy consumption, for example. That could be the next step. As partners we have lots of plans and ideas that we'll gradually be able to simulate.

As a few examples: what happens if you lay a number of larger pipes or create extra storage capacity in specific locations? What effect does uncoupling have? Where might an internal catchment be of help? If overflow is required because the rainfall is so extreme, at which location would it be best to do that where it will cause the fewest problems? And what happens if you need to use the pumping station more frequently or the opposite, less frequently? How do you prevent pumping stations pumping against each other? Is a flexible overflow a good idea?

We can still investigate all these things. Using our model we can predict what works better and subsequently put it into practice. And in turn conduct measurements and improve the model further.

Large projects also yield insights. What are three lessons you've learned here?
Marcel: You need to take a good look at where you want to control specific things. This doesn't just apply to pipes, wells and measurement systems but also to data and models. If you put everything in a single system and a data expert sets to work on it, if you input both control data and hydraulic data you run the risk of that person not knowing much about hydraulic analysis and accidentally changing something and this resulting in errors. For this reason, from the start we agreed that the hydraulic data wouldn't be inputted into the control system but into the telemetrics system. Incidentally, that decision was made before it became clear to us that with the aid of the GWSW standards a control file can also function as a calculation file. Then you realise that developments can turn out differently at different times and perhaps require adjustment at any time.

Another lesson learned is that you link it to existing operating processes. And the third lesson, which is completely logical but I want to mention it anyway, is that you record everything in a manual so that others can also use it. What's connected to what and which data sources you use etc. Record all the steps in as much detail as possible, because you don't want to rely on what someone has in their head.

Weren't you ever worried about losing data as a result of the datasets being connected? How do you retain an overview?

Marcel: No, it's true you can lose data but you build up the data collection gradually. Although the drainage experts think there's a huge amount of data, for data experts it's not that much. It's their job to keep an overview. Don't let yourself be held back by that. And data that you think 'we can't do anything with that' might well be valuable in a couple of years.

Can other municipalities also adopt your approach?

Marcel: Of course! You need to realise that we spent many years working on this, so don't expect implementation to be quick. You need to build up all the different components. We've now nearly reached the stage at which we can automatically create a new drainage model, as it were at the touch of a button. Data is growing in importance, so the first requirement is to have data on structures, surfacing, rain meters and sensors in order. Then you can start to map everything. We've already finished that process. The data checker that we developed in conjunction with Nelen & Schuurmans can be used by other municipalities as well. They can also obtain the instruments and processes from us. RIONED Foundation regulates the GWSW standards and, as I understand it, the BGT (Key Register for Large-scale Topography) import template and an automatic tool for allocating BGT surfaces are also on the way. And hopefully in Almelo we can in turn learn from others.

Towards a Delta Plan for digitising infrastructure in the

One of the biggest disasters in the history of the Netherlands struck in February 1953 when large parts of the country were flooded. This major flood was caused by a combination of extreme weather conditions and a huge backlog in maintenance as a result of post-war budget deficits. The national disaster led to the Delta Plan, in which the government and businesses united to realise a wide variety of technological innovations. These have helped to make the Netherlands a safer place and indirectly created a world-class export industry. There are many parallels between the situation seventy years ago and now. We again face an enormous maintenance challenge with only limited financial resources: hundreds of bridges, tunnels, roads, locks and other waterworks are approaching the end of their technical lifespan.

Digital innovations, such as Smart Maintenance technology, provide us with the solution. For example, sensor data from structures, which are collected and analysed elsewhere via Internet-of-Things connections, and predictions made using Artificial Intelligence (AI) on the remaining lifespan of roads, bridges and locks. This information is then used to enable targeted and timely maintenance. Maintenance that is conducted and supported by Virtual and Augmented Reality and via the use of digital twins. This digital revolution in Dutch infrastructure makes smart maintenance possible and enables us to keep the Netherlands safe, accessible and habitable. FME and World Class Maintenance (WCM)1 are therefore asking the new Dutch government to invest in smart maintenance technology via a Delta Plan for digitising infrastructure

in the Netherlands.

Please see below for the cabinet formation paper sent by FME/WCM in March 2021.

1. Challenges in Dutch infrastructure

The Netherlands is known for its sound infrastructure. A large proportion of this infrastructure has been constructed at a fast rate since the middle of the last century. This has served to make our homes and work locations safe and accessible. The Netherlands' robust economic growth has in part been enabled by this. However, this same infrastructure is now facing enormous challenges, caused by ageing and increasingly intense and heavy use.

A large proportion of the country's infrastructure was constructed in the 1960s and 1970s and has a lifespan of 50-80 years, leading to more than a third more of it requiring replacement in the period 2020-2030 than in the period 2010-2020. Maintenance of outdated assets has always been a tough financial task. This will not change over the coming decades. Expenditure on maintenance currently amounts to about EUR2.5 billion a year.

In addition to ageing, more intense use means that infrastructure is subject to quicker wear and tear and therefore requires more intense maintenance or premature renovation or replacement. Thanks to the economy picking up we are seeing both a growing number of users and growth in transport. The result is the accelerated wear and tear of infrastructure. This involves nearly 2,900 viaducts, over 1,100 bridges and 27 tunnels.

The more intensive use and the fact that many structures and assets are approaching the end of their lifespan mean that more maintenance is required and we face a major replacement and renovation task; the biggest in our history. The heightened maintenance problem is already leading to postponed and overdue maintenance. This has enormous financial consequences. In its 2019 annual report the Ministry of Infrastructure and Water Management (RWS) talks of EUR1,417 million in postponed maintenance and EUR17 million in overdue maintenance. The financial scale is only expected to grow over the coming years.

Not only do postponed and overdue maintenance lead to higher maintenance and replacement costs, they also have consequences for the accessibility of the Netherlands and in turn for the Dutch economy. Social organisations such as Mobiliteitsalliantie4, Logistieke Alliantie5 and Transport en Logistiek Nederland6 are warning against the negative economic impact of sudden work on infrastructure and argue in favour of an accelerated and programmatic approach to overdue maintenance. The expectation is that the use or operation of bridges and locks will need to be restricted more often in future, partly because wear and tear will shorten the remaining lifespan of the assets. The result will be a greater amount of disruption over the next few years. All the more so because past design decisions have not always led to infrastructure being easily and flexibly adaptable to changes and new developments. Quality standards are therefore being squeezed severely, with potentially major consequences for individual road users but also for Dutch businesses. This is what happened when the Merwede bridge near Gorinchem was closed to heavy goods vehicles in the autumn of 2016. The transport sector suffered losses of EUR33 million and the government had to pay out substantial compensation for these losses.

2. Smart maintenance as the solution

We need to make Dutch infrastructure smarter in order to prevent postponed and overdue maintenance. This can be achieved by using Smart Maintenance technology. Via the use of data, sensors and algorithms, Smart Maintenance tech-

1 FME (Dutch employers' organisation for the technology industry) has 2,200 members. World Class Maintenance is a FME network that aims to make maintenance 100% predictable, including in the infrastructure sector.

nology enables targeted and timely maintenance - neither too late nor too soon - to be conducted on infrastructure in the Netherlands.

'The added value of Smart Maintenance for infrastructure in the Netherlands' report
FME and WCM have conducted research into the added value of Smart Maintenance for infrastructure in the Netherlands. The report shows that structurally monitoring the condition of the infrastructure using via Smart Maintenance technology enables replacements to be prioritised and structures to be maintained effectively. This means that the timing of the replacement can be postponed - in a safe manner. The peak in investment can therefore be spread out over time, so that it becomes feasible within current maintenance capacity. In the longer term, Smart Maintenance offers a way of structurally reducing investment expenditure and annual management and maintenance costs. Our research revealed the following:

- Smart Maintenance technology can reduce government investment expenditure by 16% and cut management and maintenance costs by 11%. In an annual budget of EUR16 billion this translates into savings of over EUR2.2 billion per year;

- As Smart applications will need to be further developed and upscaled, we expect a quarter of this – 4% and 3% respectively – can be saved as early as in 2025, together accounting for savings of EUR600 million a year.

In short, Smart Maintenance offers a way of (1) meeting the upcoming replacement challenge by spreading investment and work over time, (2) structurally reducing annual expenditure on infrastructure and (3) increasing the accessibility and safety of infrastructure in the Netherlands. Smart Maintenance technology also gives us the opportunity to create a new Dutch export product and in doing so boost our national earning potential.

3. Develop a Delta Plan for Digitising Infrastructure

To raise quality standards for a safe, accessible and habitable Netherlands, additional efforts are required in relation to smart maintenance in order for us to be able to rise to the maintenance challenge for infrastructure in the Netherlands. The undersigned propose the following to the new Dutch government:

1. Develop a new Delta Plan for Digitising Infrastructure with the aim of making infrastructure asset management and maintenance smarter and successfully realising the widespread replacement of ageing infrastructural assets. The Delta Plan should engender a combination of data-driven traffic management and asset management. Both of these use 'talking assets', central control towers that collect and analyse these data, as well as digitally-empowered frontline staff who profit from these analyses in the field. Traffic density and maintenance are ultimately inextricably linked to each other in technical terms. This link needs to be reflected in their control.

2. Structural financing will be required for this Delta Plan to be implemented. After all, maintenance work is not a one-off but a periodical process. For the period 2022-2035, the RWS has indicated an additional budget requirement of on average an extra EUR1 billion a year compared to the current budget. We ask you to allocate at least 10% of this amount, EUR100 million a year, to the Delta Plan for Digitising Infrastructure and in doing so stimulate the use of digital technologies such as Smart Maintenance.

3. Link these activities to strategic staff planning: now and over the next ten years we will see unprecedented outflow of experienced personnel. Significant inflow of young people with digital skills is required at higher and further education level. The current workforce needs to receive training in digital skills. Organise systematic training courses on the use of these digital tools and on the new types of contractual partnerships. Make data sets containing failure data for our structures available as training data for the sector but also for industry, where sharing this type of data is more difficult than in the public sector.

2 Parliamentary document 35000-A, no. 98
3 https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2020/12/17/bijlage-1-pwclrebel-eindrapportage-instandhoudingskosten-rws/bijlage-1-pwclrebel-eindrapportage- in-standhoudingskosten-rws.pdf
4 https://mobiliteitsalliantie.nl/wp-content/uploads/2021/03/De-Mobiliteitpassage.pdf
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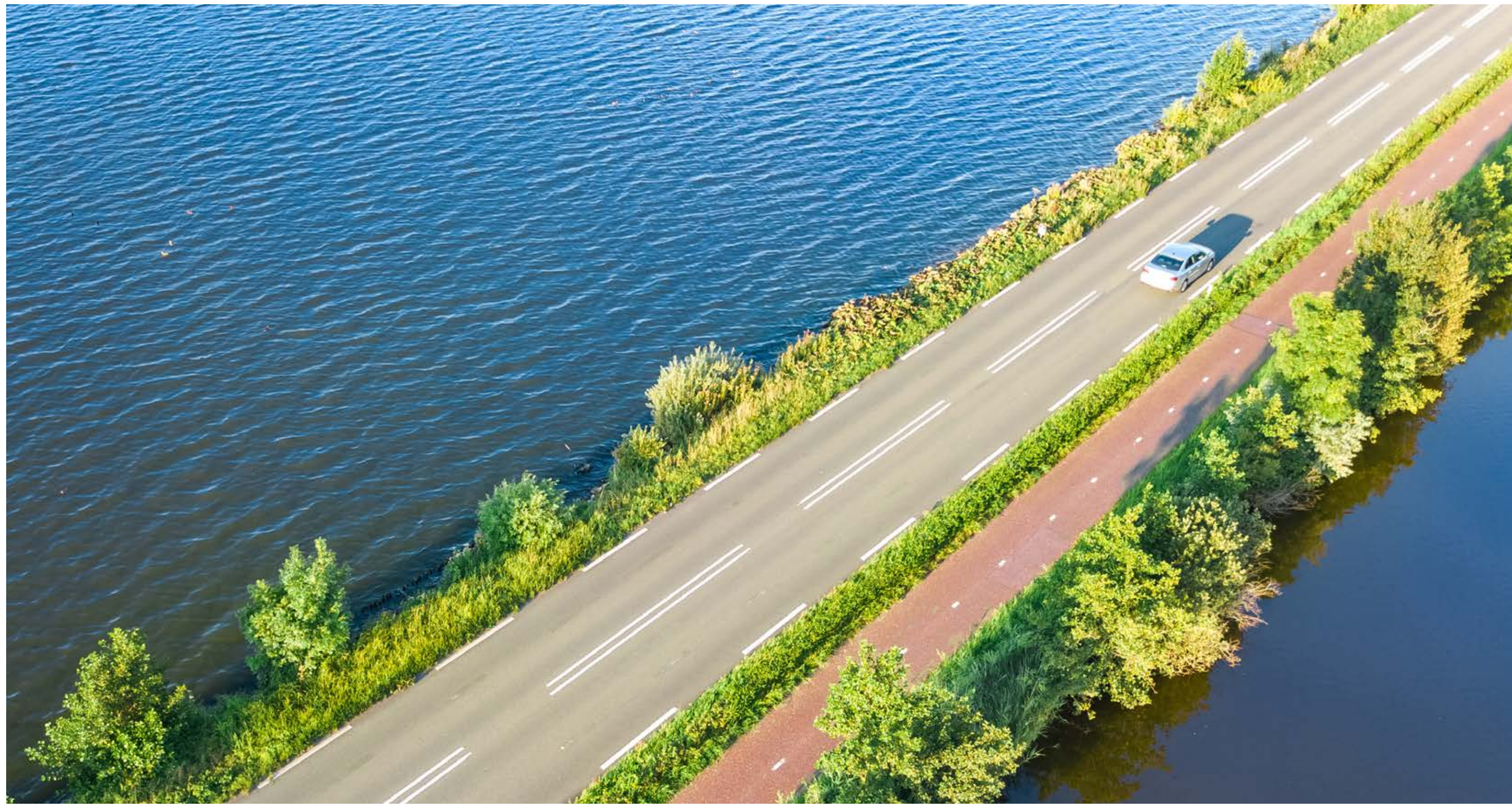

Eefde lock: national monument and gateway to Twente

Eefde lock has been the gateway to the Twente canal since 1933. The waterway traffic and water levels are regulated from the lock. Fieldlab CAMINO has used the lock as a field lab since 2017.

National monument

Eefde lock was built nearly 90 years ago to a design by architect Dirk Roosenburg. The lock underwent a thorough renovation in 2003. As the lifting mechanism was still in good condition, this was not replaced. Several emergency repairs were later carried out.

The south side of the lock is still home to a national monument: the pumping station. This pumping station pumps water back and has the important task of keeping the water at the right level.

Gateway

Eefde lock constitutes an important connection for shipping between Northern and Eastern Europe and the ports of Rotterdam, Amsterdam and Antwerp. Each year, ships carry as many as 70,000 containers and 60 million tons of cargo via Eefde lock.

Three years ago Eefde lock was designated a learning environment for Smart Maintenance. Within the field lab, organisations conduct research into technologies, such as the Internet of Things, that aim to make maintenance on the lock predictable.

New lock

The increased traffic and longer waiting times led to the decision to construct an entirely new lock alongside the old one. Consortium Lock to Twente - a partnership between TBI Foundation companies Mobilis and Croonwolter&dros - is carrying out this work on behalf of the Ministry of Infrastructure and Water Management.

Work

The following work has been conducted in the past three years:

- Renovation of the existing lock (from April/May 2020)
- Construction of a second lock chamber on the north side of the existing lock
- Construction of a new operational centre
- Construction and maintenance of a bridge over
- the new lock
- Redesign of Kapperallee
- Redesign and maintenance of the
- area to the north of the new lock
- Relocation of the primary and regional
- flood defences on the north side

Eefde lock as a learning environment

In 2017, the idea arose of using Eefde lock as a field lab for research into Smart Maintenance. The Ministry of Infrastructure and Water Management identified a unique opportunity to use the expansion of this lock complex to innovate. This project is a perfect match within the Vital Assets initiative: a Ministry of Infrastructure and Water Management programme that focuses on the effective and sustainable upscaling of Smart Maintenance.

Together with TBI Foundation companies Mobilis and Croonwolter&dros and World Class Maintenance Foundation, the Ministry of Infrastructure and Water Management took the initiative to use Eefde lock as a field lab. All the partners will benefit directly from obtaining greater insight into how the lock performs, making it easier to predict the required maintenance.

Goals

Tangible goals were set at the start of the project. These are aimed at providing insight into the factors that predict maintenance. In the case of Eefde lock these are the following areas:

1. Energy consumption

Monitor energy consumption and investigate whether there are any patterns in this. If we discover that the same consumption pattern occurs just before a component malfunctions, this is a sound indicator of an upcoming failure.

2. Corrosion formation

Establish at an early stage when corrosion will form on a component. Identifying and remedying this in good time extends the lifespan of materials.

3. Vibrations and oil quality

Analyse the number of vibrations in the lock and monitor oil quality. If, for instance, we observe a higher number of vibrations prior to a component failing, this is a sound indicator of that component's degradation.
The more accurate the information on this, the easier it will be to predict the required maintenance.

4. Data

Collect, process and visualise all measurement and regulation signals from the lock. By examining these so-called SCADA (Supervisory Control And Data Acquisition) data from machines closely, we can identify patterns that predict maintenance.

Expansion

During the field lab we reached the conclusion that it was also interesting to include the pumping station in the monitoring. On the one hand this was because the pumping station and lock are directly linked to one another. One cannot work without the other. On the other this was because the pumping station had recently been renovated and equipped with all kinds of built-in sensors. This presented a wonderful opportunity to obtain new insights fairly quickly. For example, we looked at the use of SCADA data, but also at how the pumping station and pumps are used in practice vs. their intended use – that for which they were designed.

Open data

The aim of this project is not just to make maintenance on Eefde lock predictable but also to implement this in other structures in the Netherlands. For this reason, the parties involved are proponents of open data: we share not only insights but also make the underlying data available to the market.
One major benefit of open data is that anyone - including parties not involved in this lock - can develop their innovative solutions more quickly and easily. This is how we contribute to making it easier to predict infra maintenance.

CAMINO Rail

Kilometres of rails pass under sensors

Anyone who regularly travels by train has experienced the occasional delay. Many of these delays are preventable. How? By monitoring the condition of the rails and everything around them in order to enable defects to be remedied at an early stage. And this is precisely what NS (Dutch Railways) and ProRail (rail operator) are doing within CAMINO Rail. In this project the two best-known parties in Dutch railways are joining forces to make maintenance predictable. Paul van der Voort, DataLab programme manager at ProRail, tells us more about this partnership.

"As both NS and ProRail are involved in rail infra in the Netherlands, we regularly work together. Via Leo van Dongen, the then director of NS technology, we came into contact with World Class Maintenance. We quickly decided to investigate whether it was a good idea to innovate via a Fieldlab. At a brainstorming session Inge Kalsbeek from NS and I came up with the idea of carrying out data-driven rail maintenance. For instance by measuring the condition of the rails via sensors placed on trains. Our idea was voted the best and that's why it was included in the CAMINO Rail programme."

More monitoring, fewer delays

"We started officially in January 2018. Since then we've carried out several sub-projects. The aim of each experiment is to see how we can improve monitoring of the rails. At the moment ProRail sends inspection trains along the rails to map each section in detail. Inspection trains involve extra costs and need to be scheduled around the - already crowded - passenger timetable. For this reason, these inspection trains only reach each section of the rails once or twice a year. In the meantime, something could easily fail without us being aware of it."

"By installing sensors on normal passenger trains, we can inspect the entire rail network daily. This increases the chances of us quickly identifying a defect. A defective overhead line will often halt rail traffic for hours. If we can identify this type of defect at an early stage, rail passengers will be much less affected by this. Our pilot scheme - in which we placed sensors on two NS trains - led us to carry out preventive maintenance at a location we would otherwise have missed."

Precisely on time

"We're currently using the sensors to monitor whether specific sections still meet our own quality or condition standards. If not, we replace them. The question now is how far ahead of any failure we are if a sensor detects a defect: is this a week or two years? It's important to investigate this for the future. After all, you want to carry out maintenance at precisely the right time. Not too soon, because that's a waste of money. But not too late either, because that leads to failures. We're still searching for that ideal time.

"The great thing about the partnership between NS and ProRail via CAMINO Rail is that we can act very fast. To start with in particular we benefited a lot from CAMINO's process supervision. Now we've been doing this for a couple of years, the partnership is really driving itself. Our goal is to keep failures to a minimum in the future and make maintenance predictable and more efficient. We've already demonstrated that sensors can help us in this. The next step is to do something with it on a larger scale."

Sub-project 5: Existing data sources

Goal: to discover which data NS and ProRail already collect and what they can do with them. This is how it works: many sensors are already fitted to both the rails and trains. All of these collect data. These conceal a large amount of information, as long as you know where to look.
Status: complete. The next step is to initiate new research projects with other partners from the rail sector.

Stop talking, start testing

"If you're working on innovation, it's important not to spend too much time coming up with and working out a solution, as that's often uncertain. Just set to work. Try things out, test your ideas and see what they yield. You can then progress using that information. This attitude of talking less and doing more has already yielded us a great deal."

Would you like to know more? View these videos:
Rail monitoring using sensors on the undersides of trains:
https://www.youtube.com/watch?v=WxL0APalgsI&t=2s
https://www.youtube.com/watch?v=KRAdZyISYsA&t=1s
Overhead line monitoring using sensors on the roofs of trains: https://www.youtube.com/watch?v=Wk0K-P0WR-bU

CAMINO Rail is working on these sub-projects

Sub-project 1: Wheel and rail monitoring
Goal: to monitor the rails using passenger trains.

This is how it works: using sensors on the undersides of trains you measure whether any defects can be identified in the rails. If so, we can send in a team to remedy them.

Status: experiment a success, tender ongoing. The first trains fitted with sensors will run at the end of 2022 or early 2023.

Sub-project 2: Image recognition of the overhead lines
Goal: to monitor the overhead lines in a bid to prevent failures – and therefore delays.

This is how it works: you 'view' the overhead lines using cameras on trains. The system uses automatic image recognition to detect defects.

Status: experiment ongoing. Automatic recognition of overhead line components is going well, still working on identifying the condition of the overhead lines.

Sub-project 3: Image recognition of the pantographs
Goal: to check whether the pantographs on the roofs of trains still work properly.

This is how it works: cameras along the rails film the trains as they pass by. They use automatic image recognition to detect whether the pantographs display any defects.

Status: experiment ongoing, data collection stage.

Sub-project 4: Monitoring the area around the rails
Goal: to discover whether new applications are possible by combining NS and ProRail data

This is how it works: many sensors are already fitted to both the rails and trains and a large amount of data is already collected. These conceal a large amount of information, as long as you know where to look.

Status: complete. A variety of new applications have been demonstrated. The next step is to initiate new research projects with other partners from the rail sector.

“The Netherlands has everything it needs to become a leader in predictive maintenance”

Predictive maintenance contains a huge amount of promise. Just think: the ability to halve downtime and save tens of billions of euros. Yet how can we ensure that we fulfil that promise? This is where research comes in. Mariëlle Stoelinga, a professor at the University of Twente and Radboud University in Nijmegen, is heading a large-scale academic study into predictive maintenance. She tells CAMINO about her PrimaVera research programme.

Mariëlle: “Predictive maintenance offers enormous potential. It’s one of the most important applications of the Internet of Things. McKenzie has calculated that we could save an estimated EUR63 billion on an annual basis by switching to predictive maintenance. That realisation is dawning on a growing number of people and organisations. Yet actually reaping the benefits is a different story at the moment.”

National research agenda

“The aim of PrimaVera is to investigate all aspects of predictive maintenance. Not just the sensors or data analyses but also the human factor. Because this plays a significant role in the ultimate application of all smart maintenance. PrimaVera represents the entire chain of predictive maintenance. This is essential because the decisions you make in one part have a knock-on effect on other steps in the chain: defining the types and number of sensors has an impact on your prognostics, i.e. which failure modes you can predict and which you can’t. This integral approach makes PrimaVera a unique initiative. It’s partly for this reason that this project has been placed on the national research agenda and received EUR5 million in subsidies.

“In order to be able to conduct research throughout the entire chain, those scientists who are at the top of their profession work together in a single team. Eleven industrial partners have also already signed up. They help us by providing cases from their companies. For example, we study the problems they encounter and how we can solve these problems. As PrimaVera we will then take the next step: translate this specific case into general principles. In the long term this creates a standard approach that works for everyone.”

Don’t collect random data

“The questions that occupy organisations vary widely. How can we accomplish a digital transformation? What do maintenance workers need to be able to use this type of technology properly? Who pays the costs and who will benefit most? But also: what precisely are the goals? Do you want more uptime, fewer failures or to cut your costs? These things are all linked but before you start to collect data you need to know which performance indicators to measure. There’s no point in collecting random data.

“One of the spearheads of our research is to map out the process behind the algorithm. Machine learning is often a black box at the moment: you input something and receive output at the other end. What happens in between is often a mystery. We want to make the conclusions that Artificial Intelligence draws more transparent. We do this by, for instance, combining these with physical failure models. In other words: failure models based on the laws of nature. For example, sensors often measure temperature. High temperatures predict failure. We investigate whether we can link the two.”

Get on with it

“In technological terms, we can already do a great deal to make maintenance completely predictable. But if you ask me whether we’ll be able to do without inspections entirely in five years’ time? I’m not so sure. Technologically, it’s certainly possible. Yet in the Netherlands we’re also extremely good at insisting on reaching a consensus. That’s why processes take much longer than necessary. I think we should all just throw our weight behind this and get on with it.
The Netherlands has everything it needs to become a leader. If we seize the opportunities that are ripe for the picking, predictive maintenance could easily become our new Delta Works. Then people from around the world will turn to us when they need the smartest solution.”

For more information on PrimaVera go to https://primavera-project.com/

If you have any questions about this e-magazine or would like to contribute an interview to the next edition, please contact us via camino@worldclassmaintenance.com.