



DUTCH
SAFETY BOARD

Summary Accident Den Uylbrug, Zaandam

More than the sum of its parts



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The Hague, January 2016

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Dutch Safety Board

When accidents or disasters happen, the Dutch Safety Board investigates how it was possible for them to occur, with the aim of learning lessons for the future and, ultimately, improving safety in the Netherlands. The Safety Board is independent and is free to decide which incidents to investigate. In particular, it focuses on situations in which people's personal safety is dependent on third parties, such as the government or companies. In certain cases the Board is under an obligation to carry out an investigation. Its investigations do not address issues of blame or liability.

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On 6 February 2015, a woman who was standing on the *dr. J.M. Den Uylbrug* bridge in Zaandam with her bicycle died when the bridge was opened. The bridge operator, who was operating the bridge remotely, gave the command to open the bridge while the woman was standing on the moving part of the bridge. When the bridge was raised, the woman suffered a fatal fall.

After the accident it quickly became clear that there was no technical defect in the *Den Uylbrug*, and nothing indicated that the cyclist had taken any conscious risks. More emphatically: the individuals directly involved probably thought that they acted safely. This makes the need to discover how they could have been under this impression that much more urgent. To this end, the Dutch Safety Board has investigated the system for operating the bridge. This system comprises both the technical equipment for opening and closing the bridge and the interactions between the bridge operator, road users and the environment. It is precisely these interactions that largely determine the safety of remote bridge operation. We investigated how the municipality of Zaanstad met its responsibility for the safety of the bridge operation.

Conclusions of the investigation

The municipality of Zaanstad has had an overly one-sided approach to meeting its responsibility for safe bridge operation by approaching it primarily as a technical problem. The municipality saw the safety of bridge operation as the sum of the components that result from following the applicable standards and directives. The municipality did not consider the relationship and interactions between technology, humans and the environment, while these largely determine the degree of safety of remote bridge operation. The investigation demonstrated that the layout of the *Den Uylbrug* from the road user's point of view and the execution of the operating process, the camera system and the operator's working conditions all leave room for improvement.

As a result of this one-sided focus on technical solutions, safety - for which the municipality of Zaanstad was responsible as bridge manager¹ - became the bridge operator's problem. The municipality provided the bridge operators with too few guidelines to recognize and successfully assess hazardous situations. The operator took the decision on whether a bridge could be opened safely entirely on the basis of personal experience and insight. The operator had to personally assess - given the conditions at his/her workplace and on the bridge - whether or not they were in a position to make such a decision properly.

The factors that played a role are not unique to the Zaan case. It is therefore important that other bridge managers in the Netherlands, as well as the municipality of Zaanstad, check what lessons they can learn based on this report.

¹ A bridge manager is responsible for, among other things, the safe use and maintenance of the bridge. Bridge managers are usually: The Directorate-General for Public Works and Water Management (Rijkswaterstaat), water authorities, provinces and municipalities.

Safety risks with moveable bridges

Given the abundance of water in the Netherlands, bridges are an essential link in the road network. Moreover, many bridges have to be able to open so that shipping is not hindered. The exact number is not known, but it is estimated that there are almost a thousand moveable bridges in the Netherlands. Over the last twenty years or so there has been a growing and noticeable trend to operate these bridges remotely from a central location. This centralisation of bridge operation is usually intended to improve harmonisation of bridge opening and closing and thereby speed up the flow of traffic. Cost savings also play a role: where previously bridge operators only operated their own bridge, they now work in a central operating station and are responsible for a number of bridges. This means that fewer personnel are required on balance.

Each time a bridge opens or closes, there is a disruption to road traffic - cars, cyclists, pedestrians - or shipping: if one traffic flow moves the other is blocked. So, by definition, a moveable bridge entails safety risks that do not apply to a fixed bridge. Bridge managers (as, in the case investigated, the municipality of Zaandam) are responsible for safety on and around their bridges; they should identify risks and implement suitable measures to remove these risks as much as possible.

Insufficient attention to slow traffic

The Dutch Safety Board's investigation demonstrates that the Den Uylbrug has specific features that could cause confusion amongst cyclists and pedestrians, about their precise location on the bridge for instance. This confusion could lead to behaviour that places road users in a dangerous situation without their being aware of it. The safety risks arising from this indicate a more far-reaching problem. For other bridges, within and without the municipality of Zaanstad, it is not standard practice either to investigate bridge-specific risks from the perspective of the slow road user.

There is also insufficient attention to the safety of cyclists and pedestrians in the existing regulations. Bridge design standards and directives from the Directorate-General for Public Works and Water Management specify requirements for moveable bridges in general, but do not distinguish between the various types of road users. Specific requirements or directives for cycle bridges or for the safe stopping of cyclists and other slow traffic cannot be found in this legislation.

Better support for the bridge operator

The role of the bridge operator is crucial in the process of operating bridges remotely. After all, the operator decides whether or not a bridge can be opened or closed safely. Bridge operators must, without being physically present at the bridge, be certain that the bridge is free from people and objects before they open the bridge. They depend on technical aids for doing so, and their work is influenced by the context within which they carry out their work. In addition, the bridge operator is responsible for a number of bridges and traffic volumes have increased significantly over the years. These developments have made the operator's task more difficult; this increased workload does not always go hand in hand with an appropriate level of support and supervision.

The Dutch Safety Board believes that it is important that bridge operators are better supported. They should be trained in the various scenarios that could arise. They must

be able to assess situations quickly and know how to act on a case-by-case basis. It is the bridge manager's responsibility to draw up the scenarios, to train the operators in applying them and to be alert to new risks that could lead to new scenarios. In Zaanstad, for example, not enough thought was given to the so-called man-machine interaction in the design of the camera system. Training bridge operators (using simulations) in different scenarios can facilitate measuring and improving the quality of man-machine interaction.

System approach to safety

The responsibility for the safety of bridges is vested in the bridge manager. A bridge manager should not only ensure that the bridge is technically in order and that it is well maintained; the manager must also realize that, by placing operation at a distance, a technically safe bridge becomes part of a more complex system with interaction between humans, technology and the environment. In this system, the interaction between various components of the bridge in relation to the various users and their environment has an effect on safety. Such a complex system requires an integral approach to evaluate the safety of bridges. Specifically, this involves, for instance, the layout of the bridge, including road markings on the bridge deck; the visibility of signals; the timespan between warning (light and/or audible signals) and the closing of the barriers; the display of the camera images on the operators' screens; the behaviour of the road users and the options they have for alerting the bridge operator in an emergency.

A bridge manager should ensure that they are not overly reliant on the expertise of external parties. The bridge manager, as principal, must personally specify the framework for ensuring integral safety and have a minimum level of knowledge in-house to act as a fully-fledged partner in discussions. The fact that principals are (overly) reliant on the expertise of external parties is a phenomenon that is not confined to the municipality of Zaanstad.

The Dutch Safety Board considers it to be important that the applicable regulations provide support for bridge managers in taking an integral approach to safety.

Closing remarks

There is a nationwide tendency towards further scaling-up the remote operation of bridges. This development has been prompted by the pursuit of efficiency for which a technical solution is sought. The Board questions this tendency because it is easy to lose sight of safety and the human aspect, both that of operators and that of the road users. The question is where to draw the line; not what is technically feasible but what is still humanly manageable. After all, operation is still a task for humans. In North Holland there are concrete plans to remotely operate eighty locks and bridges (including those on the Zaan) from a single location. This project of further centralisation and scaling-up creates a complex system. It provides an outstanding opportunity to take to heart the lessons from this report in regard to an integral approach to safety, better support for bridge operators and explicit attention to the safety risks of slow traffic.

RECOMMENDATIONS

There is a nationwide trend to operate more and more bridges and locks remotely. This process of increasingly far-reaching centralisation and scaling-up is driven by increased efficiency and cost savings and is based on technical solutions. Scaling-up leads to increasingly complex systems with occasionally unexpected risks. The Board therefore considers it to be important that the technical approach is expanded into an integral approach to safety, with attention to the complex interactions between humans, technology and the environment. In the end, this is about people being safe in their daily routine - as a bridge operator and as a road user - and being able to assess risks accurately. It is up to the bridge managers to implement an integral approach to safety where 'man and machine' come together and to specify the requirements for ensuring safety.

The Dutch Safety Board makes the following recommendations:

To the Minister of Infrastructure and the Environment:

1. *Ensure that the standards and directives are amended so that they support the bridge managers in setting up and implementing an integral approach to safety for remote bridge operation, where the human factors (of bridge operators and road users) are properly addressed in addition to the technical aspects.*

The standards and directives in relation to the design, use and integration of bridges must encourage bridge managers to conduct an integral evaluation of safety from the perspective of the bridge operators, slow and fast traffic and shipping.

It is also important that the actual situation at each individual bridge is identified and the applicability of regulations to this situation is determined. Currently, the same standards and directives apply to a small pedestrian bridge over a tranquil waterway as apply to a multi-lane bridge for vehicular traffic over a busy waterway alongside a railway bridge. The actions and experience of the various users (different types of road users, shipping traffic and bridge operators) of these bridges vary enormously. The standards and directives must make the situation(s) to which they apply clear and state their rationale explicitly.

2. *Ensure that knowledge about the safety risks of human actions when operating engineering structures remotely is shared. When doing so, involve knowledge from other transport sectors such as aviation and the railways.*

The Dutch Safety Board has observed that there has been insufficient research into the 'human factors' of remotely operating engineering structures, in particular regarding observation of these structures using cameras. Inspiration could be gained

from investigations conducted in other transport modalities such as air traffic control or railway traffic control.

To the municipality of Zaanstad as the bridge manager:

1. *Apply an integral approach to safety to the remote operation of bridges where the interaction between humans, technology and the environment play a central role.*

The interactions between humans, technology and the environment are largely determinative for the safety of remote operation. It is therefore important that the safety risks associated with these interactions are identified in the design of a system for remote bridge operation, in changes to that system and in its daily management. Subsequently, measures should be implemented for the risks that have been identified. When doing so, it is essential that the safety situation of each bridge is considered from the perspective of the various users. The Board emphasises that such an approach is implemented as a continuous process in which incidents are monitored and any new risks are identified.

In addition, the situation at the *Den Uylbrug* offers room for improvement when operation is considered from the perspective of the various users.

2. *Identify potentially hazardous situations and use these to define scenarios and give the operators periodic training in how to deal with them.*

Together with the bridge operators, elaborate hazardous situations, and specify how bridge operators must assess the risks in these scenarios and how they should act in response. Use these scenarios to train the operators and to support them in their task. The scenarios should include not only the risks that could occur on or near the bridge but also in the working environment of the bridge operators themselves, the man-machine interaction in particular. Keep the scenarios up-to-date based on practical experience.

The Board believes that it is important that other bridge managers check the extent to which these recommendations to the municipality of Zaanstad apply to them.



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