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CBR for Winter Road Operation at Dovrefjell

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Master of Science in Computer Science
Submission date: June 2016
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Abstract

In the winter, driving conditions can be worsened because of weather conditions. Roads that go over the tree line are particularly vulnerable to bad weather condition. In really bad weather, roads might even need to be closed for safety reasons. It is the winter road maintenance operators for each stretch of road that have to make the decision about closing a road. In Norway there are many mountain pass roads that go over the tree line. One such road is E6 over Dovrefjell. In 2006 there was an accident at this road where a bus drove of the road. At the time of the accident there were strong winds and the road was icy.

After this accident a project was started with the goal of developing better decision support tools for the operators. In this master thesis, a decision support system based on case-based reasoning is presented. The system uses historic weather data to try to decide if a road should be closed or not. Test results indicate that the decision support system presented in this thesis are able to perform better than the decision support tools used by the operators today.

Sammendrag

Om vinteren kan kjøreforhold forverres på grunn av dårlig vær. Veier som passerer over tregrensen er spesielt utsatt for dårlig vær. Hvis værforholdene er veldig dårlige må veier i blant stenges av sikkerhetsgrunner. Det er brøyte- og vedlikeholdsmannskapet for hver enkelt veistrekning som må ta avgjørelsen om en vei skal stenges. I Norge finnes det mange fjelloverganger som går over tregrensen. En av dem er E6 over Dovrefjell. I 2006 var det en buss som kjørte av veien på denne strekkningen. Ved ulykkestidpunktet var det sterk vind og is i veibanen.

Etter denne ulykken ble det startet et prosjekt for å utvikle bedre verktøy for beslutningsstøtte til brøytemannskapet. I denne masteroppgaven presenteres et system for bruk av case-based reasoning til beslutningsstøtte. Systemet bruker historiske værdata for å bestemme om en vei trenger å stenges eller ikke. Resultat fra tester viser at dette systemet har bedre ytelse enn de verktøyene som brøytemannskapet har tilgang til i dag.

Preface

This master thesis constitutes the final work of my5 year Master of Science studies in Computer Science. The work has been carried out at the Department of Computer and Information Science (IDI) at the Norwegian University of Science and Technology (NTNU), in cooperation with SINTEF.

I would like to thank my supervisor, Jo Skjermo, for his help and feedback during this work. I would also like to thank my two co-supervisors, Agnar Aamodt and Anders Kofod-Petersen, for valuable input. Finally I want to thank Finn Vassdokken at Stian Brenden Maskinservice AS for sharing his knowledge and experience regarding winter road maintenance.

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1 Introduction

In this chapter, the background for this master project is given. After that, the goal and research questions of the project are presented. This chapter will also go through the research method used and the structure of this master thesis.

1.1 Background and Motivation

In the winter, driving conditions can be worsened because of weather conditions. Roads can become slippery because of ice and snow on the road and drifting snow can, according to the Norwegian Public Road Administration (NPRA) (Statens Vegvesen, 2014c), lead to safety problems such as reduced visibility. On roads that goes over the tree line the problems with drifting snow is particularly big because of high wind speeds and large open areas where the snow can be moved by the wind (Statens Vegvesen, 2014c).

To avoid dangerous situations and accidents on roads that are exposed to weather conditions that can make driving difficult, convoy driving is sometimes needed. If driving conditions are really difficult, roads might even need to be closed. According to a document from the NPRA (Statens Vegvesen, 2002) it is the regional road administration that has the authority to introduce temporary convoy driving or closing a road. Decisions are made with the help of the winter road maintenance operators for the particular stretch of road. The document sets the following guidelines for when convoy driving and road closing should be used:

- Convoy driving should be used when weather and driving conditions are so difficult that vehicles can get stuck or there is a risk of accidents because of reduced visibility or narrow road.
- The road should be closed when bad weather or other safety problems make it too dangerous to use convoy driving.

In November 2006 there was an accident on the road E6 over Dovrefjell mountain range were a double-decker bus from Trondheim to Oslo drove of the road. The accident investigation (Statens havarikommisjon for transport, 2009) showed that the bus had been exposed to side winds of up to 25 m/s which made the front wheels lose grip on the icy road. It was concluded that in the weather conditions that was present at the accident, the bus should not have been driven over the mountain pass. The investigation of the accident also concluded that clearer directives for closing of roads in bad weather conditions are needed and that available weather measurements and forecasts need to be used more appropriately.

After the accident a project was started by the NPRA and SINTEF with the goal of developing a decision support system for when convoy driving is needed or when a road needs to be closed. In this master project, the use of case-based reasoning (CBR) in a decision support system is investigated. The master project is given by Jo Skjermo who is working on the project at SINTEF as well as being associate professor at NTNU.

In the autumn of 2015, a pre-study for this master project was conducted by Erik Gustafsson and Mikael Kolkinn. In this study, existing systems and research regarding use of artificial intelligence for road and traffic management was studied. It was concluded that inspiration and experiences can be adapted from other systems but that a decision support system for closing mountain roads is too different from other problem domains to be able to use any existing decision support system. A system designed specifically for this problem domain is therefore motivated.

According to Anders Kofod-Petersen, professor at NTNU, the project is interesting also as CBR research in general. All data that will be used in the project is collected using weather sensors. These sensors do not always give perfect measurements but have some error margins. To be able to analyse or handle these error margins in a CBR-system is interesting for CBR in general.

1.2 Goals and Research Questions

The problem description for this master project is:

> *The traffic sector is continuously logging large amounts of data about patterns and individual behaviors in the traffic (cars, pedestrians, road conditions, speed, etc.). For planning and maintenance of the traffic control systems, traffic simulators are frequently used, but their underlying models sometimes fail to capture essential elements of real world situations. The aim of this project theme is to study the use of case-based reasoning as an additional component in a decision-support system for transportation planning, traffic control, driver guidance, accident avoidance, or situation prediction.*
>
> *A demo CBR system should be developed for winter road operation at Dovrefjell, and further investigated with regards to similarity measure, case pruning, refinement of case base or case initialization.*

Based on this problem description, the following goal and research questions have been set for this project.

Goal: *Implement a CBR-system for winter road operation at Dovrefjell. The system should be able to recognize situation where the road needs to be closed or where convoy driving needs to be used.*

The CBR system that is going to be implemented is a decision support system for winter road maintenance based on measurements of weather- and road conditions.

Research question 1: *How can a CBR-system for winter road operation make use of domain specific knowledge?*

Knowledge that is relevant for winter road operation exists in many forms. Relevant knowledge can be anything from general models for weather conditions to the experiences that winter road operators have about a particular stretch of road. Also existing decision support systems used today can contain relevant knowledge. How can this knowledge be included in a CBR based decision support system?

Research question 2: *How can uncertainty in sensor values be handled in a CBR-system?*

When measuring weather parameters, there are always error margins in the sensor values. These error margins can cause uncertainty in the results produced by a CBR-system. How can these error margins be handled in a CBR based decision support system for?

1.3 Research Method

In this project, a CBR-system will be developed for the road E6 over Dovrefjell. The CBR-system will be designed by use of documented experience and guidelines from the NPRA. The current winter road maintenance operator at Dovrefjell (Stian Brenden Maskinservice AS) will also be consulted regarding experience with making decisions about closing the road. The CBR-system will be tested using weather data collected at Dovrefjell by the NPRA and the performance of the system will be compared to the performance of existing decision support systems used by the winter road maintenance operators. The possibility of using the CBR-system on roads other than E6 over Dovrefjell, and which modifications that are needed for that, will also be discussed.

1.4 Thesis Structure

This thesis consists of 6 chapters:

1. In this, the first, chapter the project is introduced and the goal for the project set.
2. In the second chapter, background theory relevant for the project is presented.
3. In the third chapter a summary of previous work within the domain is given. This includes a description of the solutions used by the operators at Dovrefjell today.
4. Chapter 4 presents the CBR-models that have been developed in this project.
5. In chapter 5, tests that have been conducted for the CBR-models are presented.
6. In the final chapter, the results of the project are evaluated and some ideas for future work are presented.

2 Background Theory

In this chapter, background theory relevant for this project will be presented. This includes theory about case-based reasoning, evolutionary algorithms and Monte Carlo simulation.

2.1 Case-Based Reasoning

Case-based reasoning, or CBR, is an artificial intelligence and machine learning method. The method is based on the idea that similar problems can be solved using similar solutions. A CBR-system keeps a database of previously solved problems/cases called a case-base. When a new problem is to be solved the system compares the new problem, the query, to the cases in the case-base and selects one or more cases to be used for the problem solving. This selection can be based on for example how similar a case is to the query or how easily the solution to a case can be adapted to the query. The selected cases are used to come up with a solution to the query. This solution can be either a reuse of one of the previous solutions or a modification of previous solutions to fit the new problem.

Machine learning methods can be classified as either eager learning methods or lazy learning methods. Eager learning methods are methods that do most of the data processing at the learning stage. That is, when the method is presented with data to learn from. Lazy learning methods are methods that do most of the data processing at the problem solving stage. That is, when the method is asked to solve a problem. CBR is a lazy learning method. When a CBR-system is presented with data to learn from it simply stores the data in the case-base. It is first when the system is asked to solve a new problem that the learned cases are processed in order to find a solution to the new problem. An advantage of the training data being processed for each query is that the processing can be adapted to each query and does not have to be done in a general way.

The fact that CBR-systems reason directly from previous cases and do not try to build a general model for the problem domain makes it suitable for applications where the system does not only need to come up with a solution but also has to give an explanation for why the solution is suitable for solving a problem. Domain models developed by some AI-methods can be hard to understand for humans which make it hard to give an explanation (that humans understand) for a suggested solution. In CBR an explanation can be given by showing which previous cases a query is similar to. I.e. the new problem can be solved by method M because a previous problem P that was similar to the new problem was solved by method M.

2.1.1 The CBR-Cycle

The CBR-cycle was introduced by Aamodt and Plaza (Aamodt & Plaza, 1994). This is a way of modelling a CBR-system. The CBR-cycle has become the general practice for modelling CBR-systems. The cycle consists of four steps which are illustrated in Figure 1.

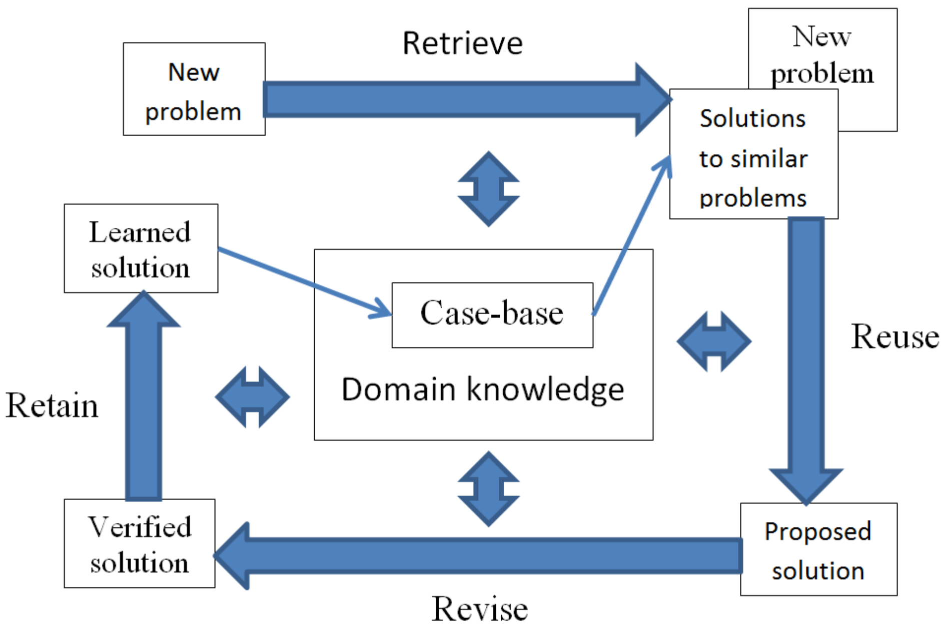

Figure 1: The CBR-cycle, adapted from Aamodt and Plaza (Aamodt & Plaza, 1994)

Retrieve: The first step when a query is given to a CBR-system is retrieving of previous cases to use for solving the query. Retrieving is often based on similarity between the query and the cases in the case-base but can also be done in other ways, for example based on which solutions that can most easily be adapted to the query.

Reuse: In the next step the cases retrieved are used to come up with a solution for the query. This solution can be a reuse of a previous solution or an adaption of previous solutions in some way.

Revise: The third step is the revise step. In this step the solution proposed in the reuse step is tested to see if it actually solves the query and, if necessary, also updated to better solve the query. This can be done in many ways, for example by letting an expert verify the proposed solution, by running the solution through a simulator or by testing the solution on the real problem to see if it works.

Retain: After a final solution to the query has been found, this solution, together with the problem description, can be stored as a new case in the case-base so that it may be used for solving future problems. It is this step that makes CBR a machine learning method and not just a problem solving method.

2.1.2 Case Representation and Similarity Function

One way in which cases and queries can be represented in a CBR-system is as a set of attribute values. Which attributes to use in a CBR-system depends on the problem domain. For example, in a CBR-system for diagnosing patients, body temperature and blood pressure are attributes that might be needed.

There are many ways in which cases that are relevant in the solving of a query can be retrieved from the case-base. One way is to retrieve cases that have similar problem description as the query. To be able to do so, some form of similarity measurement between problem descriptions is needed. If cases and queries are represented using a set of attribute values, the similarity between a case and a query can be measured using a function that compares the values of different attributes of the problem descriptions. Such a function is called a similarity function. In CBR-systems using many attributes, the number of possible similarity function can be very high. This can make it hard even for a domain expert to be able to come up with a similarity function for comparing cases and queries. In this situation, each attribute in the problem descriptions can be compared individually. A similarity between the case and the query can then be calculated as an average of the similarities for each attribute. The similarity can also be a weighted average in order to be able to increase the influence of the more important attributes. This is called the Local-Global Principle (Burkhard, 2004).

$$sim(C,Q) = \frac{\sum_{a \in attributes}(w_a * sim_a(C,Q))}{\sum_{a \in attributes} w_a}$$

Equation 1: Weighted average similarity function

Equation 1 shows the formula for a weighted average similarity function. sim(C, Q) is the similarity between a case and a query, sim_a(C, Q) is the similarity for the attribute a between the case and the query and w_a is the weight for the attribute a.

2.1.3 k-Nearest Neighbours

k-Nearest Neighbours, or k-NN, is a classification method. When a new instance of a domain is to be classified the method looks to the k already classified instances that are most similar to the new instance according to some similarity or distance metric. The new instance is classified as the same class as the majority of the k most similar instances. An example of classification by k-Nearest Neighbour is illustrated in Figure 2. In this example k=3. The new instance, X, is classified as A because the majority of the 3 nearest neighbours are of class A.

Variations of k-Nearest Neighbours exists where classifications is made in different ways than majority voting. Classification can for example be made by looking at a weighted majority where the instances closest to the new instance have a stronger vote.

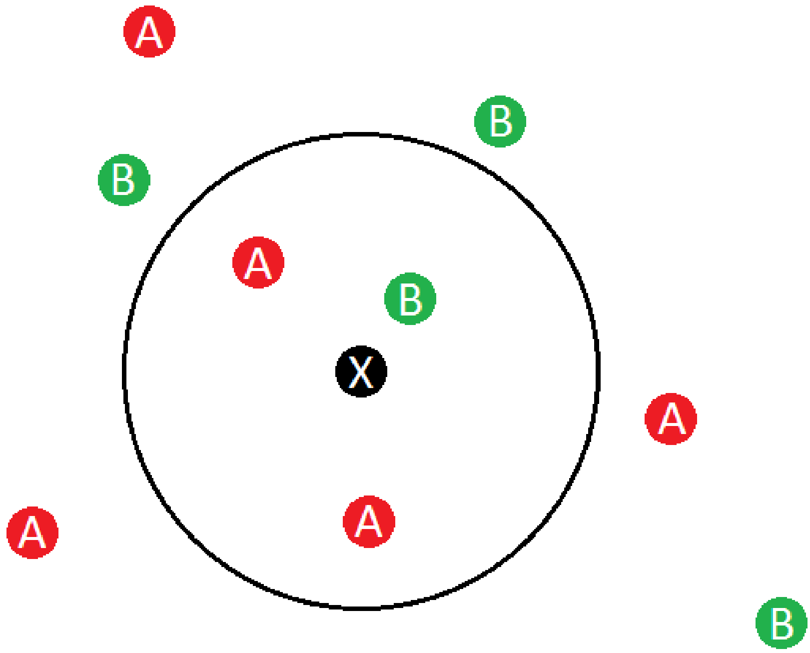

Figure 2: Example of k-Nearest Neighbours

k-Nearest Neighbours can be used as a decision rule in CBR-systems. In the retrieve step, a CBR-system can retrieve the k cases that are most similar to a query from the case-base. In the reuse step the most commonly used solution among the k cases are suggested as the solution for the query. For this decision method to work in a CBR-system the solution space of the domain has to be relatively small as the method is not able to produce any new solutions. Only reuse previous ones. Therefore all solutions need to have been used in some cases in the case-base in order for the k-Nearest Neighbours method to be able to use them.

2.1.4 Knowledge-Intensive CBR

For all types of problem solving, knowledge is needed to be able to come up with solutions. Without knowledge, only random decisions can be made. Knowledge can be expressed in many ways. For example, a problem solving system that uses a formula to come up with solutions contains knowledge in the form of the relationships between variables described by formula. In CBR, knowledge can be expressed in multiple ways. These are known as knowledge containers (Richter & Weber, 2013). Some of the fundamental knowledge containers in a CBR-system are:

- The case-base container. This is all the knowledge that is represented by the cases in the case-base. Knowledge about which solutions that were used to solve previous problems.
- The similarity container. This is the knowledge that is represented by the way in which cases are compered to queries. The knowledge of knowing which cases are similar to a query. This can, for example, be in the form of a similarity function.
- The adaption container. This is the knowledge that is represented by the way in which previous solutions can be reused or adapted to solve new problems. The knowledge of knowing how to come up with a solution based on the cases that, according to the similarity container, are similar to the query.

In knowledge-intensive CBR-systems, knowledge about the specific domain that the system is operating in is used in the different knowledge containers. In the case-base container, domain knowledge can be used to derive new attributes from existing ones. This is useful in systems where a derived attribute is more relevant for the problem solving than any of the existing attributes are on its own. If, for example, traveling time is an important but unknown attribute while both distance and speed are known attributes, the traveling time can be calculated by use of domain knowledge.

2.2 Evolutionary Algorithms

An evolutionary algorithm is a search method that is based on the idea of evolution by natural selection. An evolutionary algorithm uses the following steps when searching for a solution to a problem:

1. Generate a set of random solutions (a population) for the problem.
2. Test how good each of the solutions in the population are.
3. If any of the solutions in the population is good enough then terminate the search and use that solution.
4. Generate a new population by combining the best solutions from step 2 (crossover) and by randomly altering solutions (mutation).
5. Go to step 2.

The idea is that by always combining the solutions that works best, the algorithm will eventually end up with a good solution.

Evolutionary algorithms can be used in the development of CBR-systems to search for optimal attribute weights for similarity functions (Jarmulak, Craw, & Rowe, 2000). The attribute weights of a similarity function are important parameters. If optimal attribute weights can be found, this can greatly improve the performance of a CBR-system. When used for finding attribute weights, the 5 steps of the evolutionary algorithm then become:

1. Generate a random population of attribute value sets.
2. Test how good a CBR-system performs on some training data using each of the attribute value sets.
3. If any of the attribute value sets is good enough then terminate the search and use that set of attribute values.
4. Generate a new population by combining the best attribute value sets from step 2 (crossover) and by randomly altering attribute values (mutation).
5. Go to step 2.

In step 3, it can be hard to determine what a good enough solution to terminate the search is. The search can instead be terminated when there is no progress in the search anymore. That is, when the performance is not increasing.

2.3 Monte Carlo Simulation

Monte Carlo simulation is a method for approximating probability distributions of variables. It relies on random sampling for finding probability distributions. By repeatedly sampling a variable, a distribution of the samples is found. As the sampling is repeated more and more times, the distribution of the samples will more and more likely converge towards the probability distribution of the variable. For example, if rolling a dice over and over again, the proportion of sixes that is rolled will eventually converge towards the probability of getting a six (which is 1/6 for a normal dice).

Monte Carlo simulation can also be used to approximate the probability distribution of variables that can be calculated from other variables with known probability distributions. Assuming A and B are two variables with known probability distributions and that C is a variable that can be calculated from A and B. The variable C can be sampled by sampling A and B (according to their probability distribution) and then calculating C. The probability distribution of C can therefore be approximated using Monte Carlo simulation.

An advantage of Monte Carlo simulation is that it can be used to find probability distributions in situations where it is difficult to find the probability distribution analytically. If, for example, the relation between the variables A, B and C above is too complex for finding the probability distribution of C analytically then Monte Carlo simulation can be used. A drawback of Monte Carlo simulation is that it can be time consuming if a high number of samples are needed to give a good enough approximation of a probability distribution.

3 Related Work

In the pre-study for this master project, existing systems and research regarding use of artificial intelligence for road and traffic management were studied. This chapter gives a short summery of existing systems and research within this domain. This chapter also describes the decision support tools that are available to the winter road maintenance operators at Dovrefjell today.

3.1 Artificial Intelligence in Road and Traffic Management

Artificial intelligence is being used for many different applications within the road and traffic domain. One application is to predict or estimate road surface conditions. Shao (Shao, 1998) uses an artificial neural network for predicting road surface temperatures and icy road conditions. Mahoney and Myers (Mahoney & Myers, 2003) presents a system for maintenance decision support. The system uses models and rules to evaluate and predict weather and road conditions and to suggest actions. In an improved version of the system (Mahoney III et al., 2005), the system is also able to predict effects that storms have on the road surface. Gustavsson and Bogren (Gustavsson & Bogren, 2007) also presents a system for predicting slippery road conditions.

Artificial intelligence can also be used for traffic regulation. Fahmy (Fahmy, 2008) are using weather measurements in an artificial neural network to come up with recommended speed limits for cars and trucks. Kim, Mahmassani, Hou and Alfelor (Kim, Mahmassani, Hou, & Alfelor, 2014) presents a decision support system for optimizing time schedules for traffic lights. This system gives the operators suggestions to which timing schedules to use in a light regulated crossing. It also lets the operator simulate different timing schedules to see which one are the most effective for the current situation.

A third application for artificial intelligence that is indirectly linked to roads and traffic is avalanche forecasting. Gassner and Brabec (Gassner & Brabec, 2002) are using k-Nearest Neighbours to evaluate the risk of avalanches. This can be used to decide if houses need to be evacuated, roads need to be closed or if an avalanche should be manually triggered. Möhle, Bründl and Beierle (Möhle, Bründl, & Beierle, 2014) are using balanced random forest and weighted random forest for avalanche forecasting. Their system is able to recognize 50% of avalanches, which is about the same as a human expert.

3.2 Current Solution at Dovrefjell

To help road maintenance operators, the NPRA have written manuals for road operation and maintenance. The manual Håndbok R610 (Statens Vegvesen, 2014a) contains standards for operation and maintenance of national roads. These include standards for winter road maintenance. When operators are taking decisions about closing a road or not, there are guidelines, set up by the NPRA, to follow (Statens Vegvesen, 2002). These guidelines are however very vague and it is basically up to the operators to make the decision.

The NPRA are continuously putting up new weather stations on roads that are vulnerable to weather conditions (Statens Vegvesen, 2014b). The measurements from these weather stations can be used by the operators when deciding if a road should be closed. On the E6 road over Dovrefjell there are four weather stations, Fokstugu, Avsjøen, Hjerkinn and Grønnbakken (Engen, Skjermo, & Opland, 2015). To help operators at Dovrefjell analyse the weather data, models and formulas have been developed for calculating recommended speed limits for cars and buses on the road and for suggesting if the road needs to be closed. These models have been implemented in a mobile application that the operators can use (Engen et al., 2015). The mobile application does not collect data from the weather stations automatically but relies on the operators to type data from the weather stations into the application. According to the current operators at Dovrefjell (Stian Brenden Maskinservice AS), the application is only used occasionally because the data has to be entered manually.

4 CBR-Models

In this chapter, two different CBR-models for decision support at Dovrefjell will be purposed. There will also be purposed a method for handling uncertainty in sensor values for CBR-systems.

4.1 CBR-Model 1

The first CBR-model is a model where each attribute in the case and query representation is measured directly with a sensor. No derived attributes are used in this model. This means that no additional domain knowledge (apart from the sensor values) is added to the case-base knowledge container in this CBR-model.

4.1.1 Case Representation

According to (Engen et al., 2015), the most important parameters for deciding if a road should be closed is wind speed, wind direction, friction, temperature and visibility. This is also confirmed by Stian Brenden Maskinservice AS. For this project, all of these parameters are available from sensor data except visibility. Because of this, the other four parameters have been chosen as attribute types in this model. Each of the attribute types are measured at three different locations (Avsjøen, Fokstugu and Hjerkinn) except for friction which is only measured at Avsjøen and Fokstugu. This means that cases are represented by a total of 11 attributes. In addition, each case has a decision attribute which represent the decision that was taken by the operators in that situation. The decision attribute is therefore not a normal attribute but the attribute that the model will try to find for new queries. All the attributes of this model are summarized in Table 1.

Attribute	Domain	Unit
Wind Speed Avsjøen	0 – ∞	m/s
Wind Speed Fokstugu	0 – ∞	m/s
Wind Speed Hjerkinn	0 – ∞	m/s
Wind Direction Avsjøen	0 – 360	°
Wind Direction Fokstugu	0 – 360	°
Wind Direction Hjerkinn	0 – 360	°
Friction Avsjøen	0 – ∞	
Friction Fokstugu	0 – ∞	
Temperature Avsjøen	0 – ∞	°C
Temperature Fokstugu	0 – ∞	°C
Temperature Hjerkinn	0 – ∞	°C
Decision	OPEN, CONVOY, CLOSED	

Table 1: Attributes of CBR-model 1

4.1.2 Similarity Function

The similarity function used in this model is a weighted average of the similarity of each attribute, as described in section 2.1.2. This means that each attribute has its own similarity function and that the total similarity between a case and a query is a weighted average of these similarity functions as shown in Equation 1. The similarity functions for the attributes have been developed with help from Stian Brenden Maskinservice AS.

For all attributes, the similarity function can be written in the form of Equation 2.

$$sim_a(C, Q) = 1 - dist_a(C, Q)$$

Equation 2: Attribute similarity function

In this equation, $dist_a(C, Q)$ is a distance function for the attribute. For all attributes the range of the similarity function should be [0, 1]. Therefore all values below 0 will be rounded up to 0 and all values above 1 will be rounded down or 1. For many of the attributes the distance function is not linear to the difference between the two values that are compared. Instead the distance function is the difference between the values of an attribute specific function, $f_a(x)$, where x is the attribute value. This is shown in Equation 3.

$$dist_a(C, Q) = |f_a(C) - f_a(Q)|$$

Equation 3: Attribute distance function

The functions, $f_a(x)$, for the attributes have been found by the help of Stian Brenden Maskinservice AS. Worth noting is that the function values of these functions have no meaning other than in comparison with another value. For example, a function value $f_a(C)$ do not have any other meaning than that the case is similar to a query with similar function values.

4.1.2.1 Attribute Weights

For the CBR-model to work, the attribute weights, w_a, in Equation 1 need to be set in such a way as to optimize the similarity function. To do this, an evolutionary algorithm is used (as described in section 2.2). In the evolutionary algorithm, each attribute weight is represented by 8 bits. This means that the weights can take any value from 0 to 255. The weights found by the evolutionary algorithm, w'_a, are then normalized so that they sum up to 1 using Equation 4.

$$w_a = \frac{w'_a}{\sum_{a \in attributes} w'_a}$$

Equation 4: Attribute weight normalization

For finding the attribute weights, the evolutionary algorithm uses the training data set, which will be described later in section 5.1.2.

The attribute weights found be the evolutionary algorithm for this model are shown in Table 2.

Attribute	Weight
Wind Speed Avsjøen	0.001
Wind Speed Fokstugu	0.001
Wind Speed Hjerkinn	0.016
Wind Direction Avsjøen	0.002
Wind Direction Fokstugu	0.050
Wind Direction Hjerkinn	0.018
Friction Avsjøen	0.001
Friction Fokstugu	0.122
Temperature Avsjøen	0.233
Temperature Fokstugu	0.277
Temperature Hjerkinn	0.279

Table 2: Attribute weights of CBR-model 1

4.1.2.2 Decision Dependent Similarity Functions

According to guidelines from the NPRA (Statens Vegvesen, 2002), convoy driving should be used when the driving conditions are not good enough for keeping the road open. The road should be closed when the conditions are not good enough for convoy driving. This means that the three possible decisions for the CBR-model can be ordered. The road should be open in good conditions, closed in bad conditions and convoy driving should be used when conditions are somewhere in between. From this, the assumption can be made that if the road was open during conditions, W, then it should be open as long as the conditions are at least as good as W. Similarly, if the road was closed during conditions, W, then it should be closed as long as the conditions are at least as bad as W.

For some attribute types it can, according to Stian Brenden Maskinservice AS, be assumed that driving conditions follow a monotonic function of the attribute value. This means that as the attribute value goes in one direction (up or down, depending on the attribute) the driving conditions only get worse. In this model there are three attribute types with this property, wind speed, wind direction and friction. For wind speed the conditions get worse with higher attribute value (assuming all other attributes stay the same). For friction the conditions get worse with lower attribute value. For wind direction the conditions get worse with higher angle between the wind direction and the road. As the wind direction is measured relative to north, the wind direction needs to be converted to wind direction relative to the road. This will be described in section 4.1.2.4.

Because of these assumptions, cases where the road was open are relevant to look at even if…

- … the query wind speed is lower than the case wind speed.
- … the query friction is higher than the case friction.
- … the query wind direction is smaller than the case wind direction.

Similarly, cases where the road was closed are relevant to look at even if…

- … the query wind speed is higher than the case wind speed.
- … the query friction is lower than the case friction.
- … the query wind direction is greater than the case wind direction.

This means that the wind speed similarity should be 1 if either:

- The case decision is open and the query wind speed is lower than the case wind speed.
- The case decision is closed and the query wind speed is higher than the case wind speed.

The friction similarity should be 1 if either:

- The case decision is open and the query friction is higher than the case friction.
- The case decision is closed and the query friction is lower than the case friction.

The wind direction similarity should be 1 if either:

- The case decision is open and the query wind direction is smaller than the case wind direction.
- The case decision is closed and the query wind direction is greater than the case wind direction.

This gives similarity functions for wind speed, friction and wind direction that is dependent on the decision in the case. Figure 3 illustrates this for wind speed. When comparing a query to an open case, the similarity decreases when the query wind speed is greater than the case wind speed (blue graph). When comparing a query to a closed case, the similarity decreases when the query wind speed is smaller than the case wind speed. For convoy driving the similarity decreases both ways because as the driving conditions get better/worse the road will eventually be opened/closed.

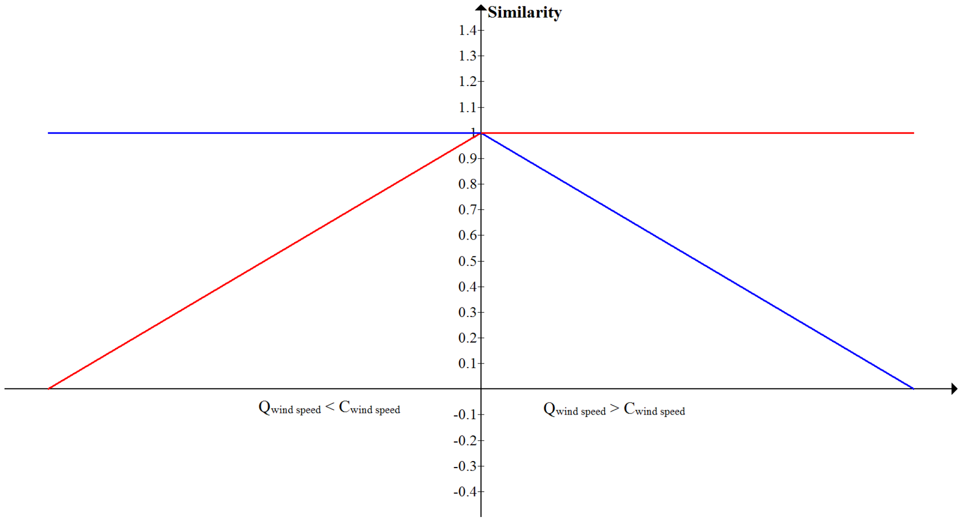

Figure 3: Decision dependent similarity function

4.1.2.3 Similarity Function: Wind Speed

As described in section 4.1.2.2, the similarity function for wind speed depends on the decision in the case that the query is compared to. If the query is compared to an open case and the query wind speed is less than the case wind speed or if the query is compared to a closed case and the query wind speed in greater than the case wind speed the similarity is 1. Otherwise the similarity function can be written in the form described in Equation 2 and Equation 3. Together with Stian Brenden Maskinservice AS it has been found that the function, $f_{wind\ speed}(x)$, in Equation 3 should be a sigmoid function. Equation 5 shows this function.

$$f_{wind\ speed}(x) = \frac{2}{1 + e^{-\frac{x-12.5}{5}}}$$

Equation 5: f-function for wind speed similarity

Figure 4 illustrates how the wind speed distance between a query and a case is calculated.

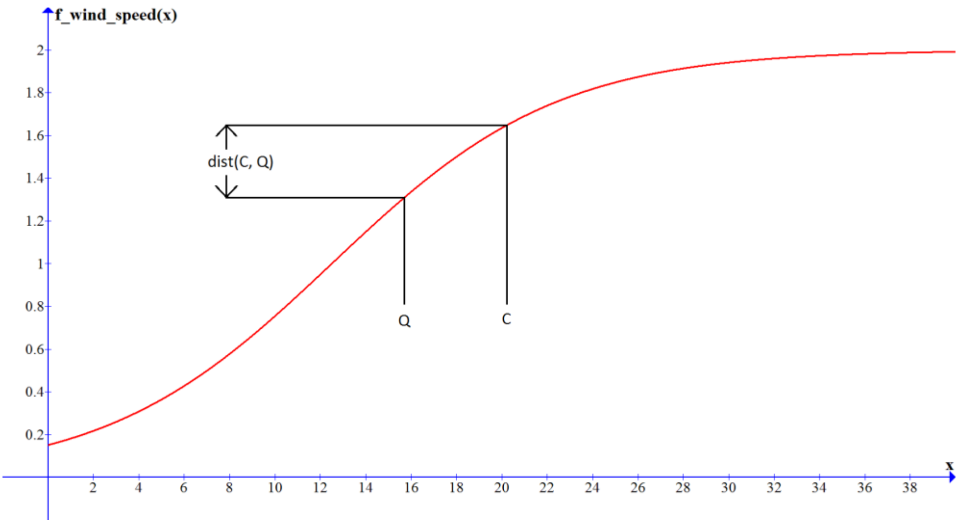

Figure 4: Wind speed distance function

4.1.2.4 Similarity Function: Wind Direction

According to Stian Brenden Maskinservice AS, the wind direction relative to the terrain is not important. What is important is the wind direction compared to the road. The absolute wind direction is therefore converted to wind direction relative to the road. This gives a range of 0° – 90° where 0° means that the wind direction is parallel to the road and 90° means that the wind direction is perpendicular to the road. To calculate the road relative wind direction the direction of the road is needed. These have been found for the different weather stations using Google Compass ('Google Compass', 2016). The road direction for Avsjøen is 60°, for Fokstugu it is 45° and for Hjerkinn it is 0°.

As described in section 4.1.2.2, the wind direction similarity between a query and a case is 1 if the case decision is open and the query wind direction is smaller than the case wind direction or if the case decision is closed and the query wind direction is greater than the case wind direction. Otherwise the similarity function for wind direction uses the distance function in Equation 6 where C and Q are wind directions in case and query relative to the road.

$$dist_{wind\ direction}(C,Q) = \frac{|C-Q|}{90}$$

Equation 6: Wind direction distance function

This equation gives a linear similarity function where equal wind direction gives similarity 1, 45° difference in wind direction gives similarity 0.5 and 90° difference in wind direction gives similarity 0.

4.1.2.5 Similarity Function: Friction

As described in section 4.1.2.2, the friction similarity between a query and a case is 1 if the case decision is open and the query friction is higher than the case friction or if the case decision is closed and the query friction is lower than the case friction. Otherwise the similarity function for friction can be written on the form of Equation 2 and Equation 3. Together with Stian Brenden Maskinservice AS it has been found that the function, $f_{friction}(x)$, in Equation 3 should be a logarithmic function as described in Equation 7.

$$f_{friction}(x) = log_4\, x$$

Equation 7: f-function for friction similarity

Figure 5 illustrates how the friction distance between a query and a case is calculated.

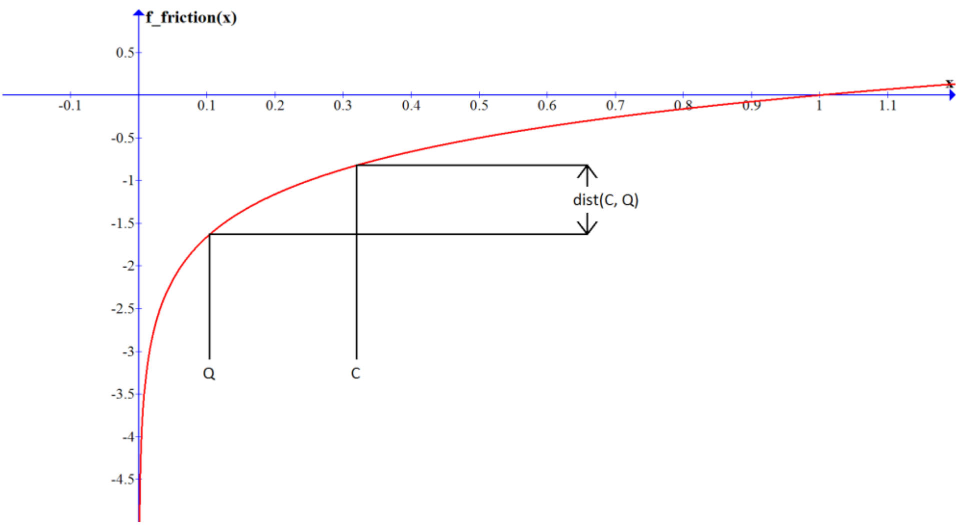

Figure 5: Friction distance function

4.1.2.6 Similarity Function: Temperature

The similarity function for temperature does not depend on the decision in the case but can always be written on the form of Equation 2 and Equation 3. Together with Stian Brenden Maskinservice AS it has been found that the function, $f_{temperature}(x)$, in Equation 3 should be a sigmoid function described in Equation 8.

$$f_{temperature}(x) = \frac{2}{1 + e^{-\frac{x}{2}}}$$

Equation 8: f-function for temperature similarity

Figure 6 illustrates how the temperature distance between a query and a case is calculated.

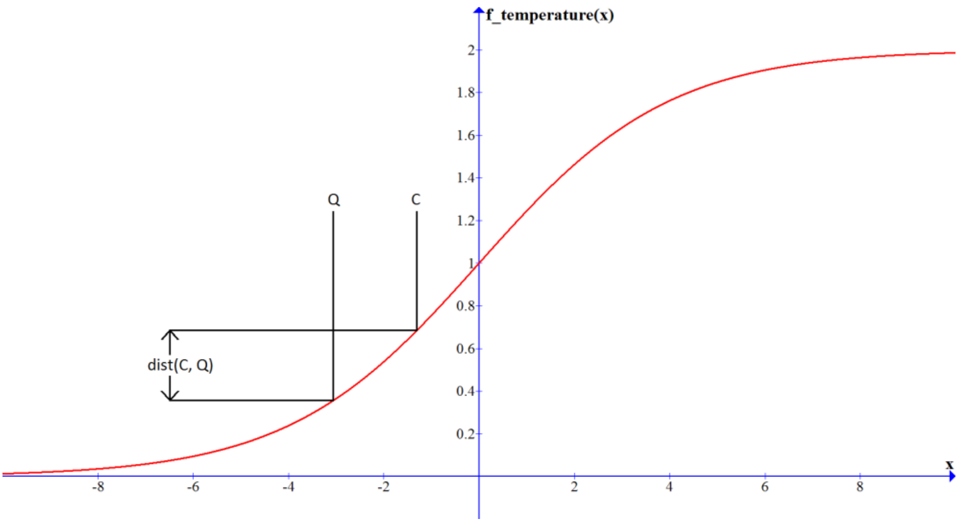

Figure 6: Temperature distance function

4.1.3 Decision Rule

To make a decision regarding whether the road should be open, closed or if convoy driving should be used, the nearest neighbour method is used, as described in section 2.1.3. This means that the case in the case-base that has the highest similarity compared with the query is selected. It is then suggested to use the same decision for the query as was used in that case. The decision is only based on the nearest neighbour. This has been chosen because of the relatively small amount of previous cases that are available. Using a bigger neighbourhood means that cases with lower similarity will be in the neighbourhood. These cases might not be relevant in the decision making as they might be too different from the query.

4.2 CBR-Model 2

The second CBR-model is an extended version of the first model. In addition to the four attribute types in the first model (wind speed, wind direction, friction and temperature) this model also makes use of derived attributes. These are attributes that are not measured directly by sensors but instead is calculated from other attributes. By calculating new attributes, additional domain knowledge is added to the case-base knowledge container in the CBR-model.

4.2.1 Case Representation

In this model, all of the 11 attributes of the first model are used. In addition to this some extra attributes are used. According to (Engen et al., 2015), visibility is an important parameter for deciding if a road should be closed. For this project, there is no data available for visibility. It is however, possible to estimate visibility based on other parameters that are available (Matsuzawa & Takeuchi, 2002). Because of this, visibility is used as an attribute type in this model. To be able to estimate the visibility, the parameters wind speed, precipitation and temperature are needed. These parameters are available for all three of the weather stations which mean that visibility can be used as an attribute for all three locations.

The mobile application used by the operators at Dovrefjell today (described in section 3.2) calculates a recommended speed limit and uses that to decide if the road should be closed. The fact that this is used today suggests that the recommended speed limit calculated by the application is relevant when deciding if a road should be closed. Therefore, recommended speed limit is used as an attribute type in this model. The parameters needed to calculate a speed limit is only available at Avsjøen and Fokstugu so speed limit can only be used as an attribute at these two locations.

The case representation for this model consists of a total of 16 attributes. These attributes are shown in Table 3.

Attribute	Domain	Unit
Wind Speed Avsjøen	0 – ∞	m/s
Wind Speed Fokstugu	0 – ∞	m/s
Wind Speed Hjerkinn	0 – ∞	m/s
Wind Direction Avsjøen	0 – 360	°
Wind Direction Fokstugu	0 – 360	°
Wind Direction Hjerkinn	0 – 360	°
Friction Avsjøen	0 – ∞	
Friction Fokstugu	0 – ∞	
Temperature Avsjøen	0 – ∞	°C
Temperature Fokstugu	0 – ∞	°C
Temperature Hjerkinn	0 – ∞	°C
Visibility Avsjøen	0 – ∞	m
Visibility Fokstugu	0 – ∞	m
Visibility Hjerkinn	0 – ∞	m
Speed limit Avsjøen	0 – 80	km/h
Speed limit Fokstugu	0 – 80	km/h
Decision	OPEN, CONVOY, CLOSED	

Table 3: Attributes of CBR-model 2

4.2.1.1 Visibility Estimation

According to (Engen et al., 2015), visibility is one of the most important parameters for if a road needs to be closed or not. At E6 over Dovrefjell, visibility sensors have been installed. These have however not been in operation long enough to have collected enough data to be able to use it in a CBR-system and in particular, use it in the development and testing of a CBR-system. Because this parameter is so important, it is preferred that it can be used in a CBR-system after the sensors have been in operation for some time. To be able to use visibility as an attribute in this project, an estimation of the visibility, based on some of the other sensor readings, are used instead.

Matsuzawa and Takeuchi (Matsuzawa & Takeuchi, 2002) presents a method for estimation of visibility in locations where the visibility is reduced by snow fall and by snow that blows with the wind.

The visibility can be calculated using Equation 9.

$$log(visibility) = -0.773 * log(wind\ speed * snow\ concentration) + 2.845$$

Equation 9: Visibility estimation with drifting snow

The snow concentration can be calculated using Equation 10.

$$snow\ concentration = \frac{P}{w_f} + \left(N_t - \frac{P}{w_f}\right)\left(\frac{Z}{Z_t}\right)^{-\frac{w_b}{kU}}$$

Equation 10: Snow concentration with drifting snow

In this equation:

- P is the precipitation in grams per second.
- w_f is the falling speed for snow fall (1.2 m/s).
- w_b is the falling speed for drifting snow (0.35 m/s).
- Z is the height at which the visibility is to be calculated. In this project 1.6 m is used as that is a typical eye level for a car driver.
- N_t is the snow concentration at the reference height, Z_t. N_t = 30 and Z_t = 0.15 m.
- k is Karman's constant, 0.4.
- U is called friction velocity and is calculated using Equation 11.

$$U = \frac{k * wind\ speed}{ln\left(\frac{Z_{wind\ speed}}{Z_0}\right)}$$

Equation 11: Friction velocity

In Equation 11, $Z_{wind\ speed}$ is the height at which the wind speed is measured (10 m for the weather stations of the NPRA) and Z_0 is called the roughness constant and is $1.5*10^{-4}$ m.

If the temperature is above -2 °C or if the wind speed is lower than 8.5 m/s then drifting snow will not occur. In this case Equation 12 and Equation 13 can be used instead.

$$log(visibility) = -0.773 * log\left(\sqrt{wind\ speed^2 + w_f^2} * snow\ concentration\right) + 2.845$$

Equation 12: Visibility estimation without drifting snow

$$snow\ concentration = \frac{P}{w_f}$$

Equation 13: Snow concentration without drifting snow

4.2.1.2 Speed Limit Calculation

One of the tools used by the winter road maintenance operators at Dovrefjell today is a mobile application for calculating the recommended speed limit on the road (Engen et al., 2015). This mobile application calculates a recommended speed limit based on wind speed, visibility and friction on the road. The speed limit can be reduced because of 2 reasons:

- Reduced stopping distance as a result of low friction and low visibility.
- Reduced road grip because of low friction and strong winds.

The algorithm used in the application calculates the speed limits based on these two reasons separately. The lowest of the speed limits are then recommended.

Let us first look at reduced speed limit caused by low friction and low visibility. A vehicle should always be able to stop for obstacles seen on the road. If the visibility on the road is low the speed needs to be reduced in order for the driver to be able to stop within the line of sight. Because there is traffic going in both directions of the road, two vehicles going in different directions must be able to stop in a combined distance less than the line of sight. A vehicle should therefore be able to stop within half the line of sight. In the formula used in the application, an additional 10 meters safety distance is added. The application also makes use of the friction of the road. The lower the friction is the longer the stopping distance becomes. The speed therefore needs to be reduced when the friction is low for the vehicles to be able to stop within line of sight. The formula for calculating the recommended speed limit based on visibility and friction can be seen in Equation 14. g is the gravity, 9.81 m/s^2, and r is the reaction time, 1 s.

$$speed\ limit_{visibility,friction} = 3.6 * friction * g * \left(\sqrt{r^2 + \frac{visibility - 10}{friction * g}} - r \right)$$

Equation 14: Visibility and friction based speed limit

Now, let us look at reduced speed limit caused by low friction and strong winds. In this case the application calculates two recommended speed limit, one for regular buses and one for double-decker buses. No speed limit is calculated for cars as it is assumed that they have good enough aerodynamics not be affected by winds in the same extent as buses. The speed limit that is calculated for regular buses are always at least as high as the speed limit calculated for double-decker buses. As only the lowest recommended speed limit is used in this project, only the recommended speed limit for double-decker buses needs to be used. To calculate this, Table 4 is used.

	Speed limit					
Wind speed	**80**	**70**	**60**	**50**	**40**	**30**
0.0-8.3	0.130	0.100	0.095	0.090	0.088	0.084
8.4-10.0	0.160	0.130	0.120	0.110	0.100	0.090
10.1-11.7	0.192	0.162	0.148	0.133	0.120	0.108
11.8-13.3	0.230	0.200	0.180	0.160	0.145	0.130
13.4-15.0	0.275	0.235	0.215	0.190	0.178	0.150
15.1-16.7	0.325	0.275	0.250	0.225	0.210	0.175
16.8-18.3	0.370	0.315	0.288	0.260	0.240	0.205
18.4-20.0	0.430	0.355	0.328	0.300	0.275	0.245
20.1-21.7	0.490	0.410	0.380	0.350	0.320	0.290
21.8-23.3	0.550	0.450	0.420	0.390	0.360	0.330

Table 4: Wind speed and friction based speed limit

First, the current wind speed is match with the wind speed interval of one of the rows. If the wind speed is above 23.3 m/s, the speed limit is set to 0 km/h. Second, the columns of the selected row are examined in order to find the leftmost column with a value less than the current friction value. If the friction is lower than the value of the rightmost column, the speed limit is set to 0 km/h. Third, the speed limit associated with the column found in the second step is recommended.

4.2.2 Similarity Function

The similarity function for this model is based on the same equations (Equation 1, Equation 2 and Equation 3) as the similarity function for the first CBR-model. The attribute functions for the four types of attributes that was used in the first model are also used in this model. These are the attribute functions for wind speed (4.1.2.3), wind direction (4.1.2.4), friction (4.1.2.5) and temperature (4.1.2.6).

There are two new types of attributes in this model compared to the first model. These are visibility and speed limit. The similarity functions for both of these attribute types are (like the attribute similarity functions in the first model) developed by the help of Stian Brenden Maskinservice AS and are also based on Equation 2 and Equation 3. For both of these attribute types, similarity functions that are dependent on the case decision (as described in section 4.1.2.2) are used. For visibility attributes it can be assumed that driving conditions gets worse with shorter line of sight. For speed limit attributes it can be assumed that driving conditions gets worse when a lower speed limit is recommended.

4.2.2.1 Attribute Weights

The attribute weights for this model are found in the same way as the attribute weights for the first model (4.1.2.1). That is, by the use of an evolutionary algorithm. Each attribute is also in this case represented by 8 bits and the attribute weights are normalized using Equation 4. Also for this model the data set used in the evolutionary algorithm is the training data set, which will be described later in section 5.1.2.

The attribute weights found by the evolutionary algorithm for this model are shown in Table 5.

Attribute	Weight
Wind Speed Avsjøen	0.000
Wind Speed Fokstugu	0.003
Wind Speed Hjerkinn	0.042
Wind Direction Avsjøen	0.001
Wind Direction Fokstugu	0.044
Wind Direction Hjerkinn	0.004
Friction Avsjøen	0.008
Friction Fokstugu	0.102
Temperature Avsjøen	0.188
Temperature Fokstugu	0.202
Temperature Hjerkinn	0.201
Visibility Avsjøen	0.000
Visibility Fokstugu	0.011
Visibility Hjerkinn	0.039
Speed limit Avsjøen	0.151
Speed limit Fokstugu	0.004

Table 5: Attribute weights of CBR-model 2

4.2.2.2 Similarity Function: Visibility

As mentioned in section 4.2.2, the driving conditions are assumed to become worse the shorter the line of sight is. This means that a decision dependent similarity function, as described in section 4.1.2.2, can be used. A case where the road was open is still relevant for decision making even if the visibility is higher in the query than in the case. The visibility similarity between a query and an open case is therefore 1 if the query visibility is higher than the case visibility. Similarly, a closed case is still relevant for decision making even if the visibility is lower in the query than in the case. The visibility similarity between a query and a closed case is therefore 1 if the query visibility is lower than the case visibility.

If none of the above rules for when the similarity should be 1 can be applied the visibility similarity is calculated using Equation 2, Equation 3 and Equation 15.

$$f_{visibility}(x) = log_4 x$$

Equation 15: f-function for visibility similarity

Figure 7 illustrates how the visibility distance between a query and a case is calculated.

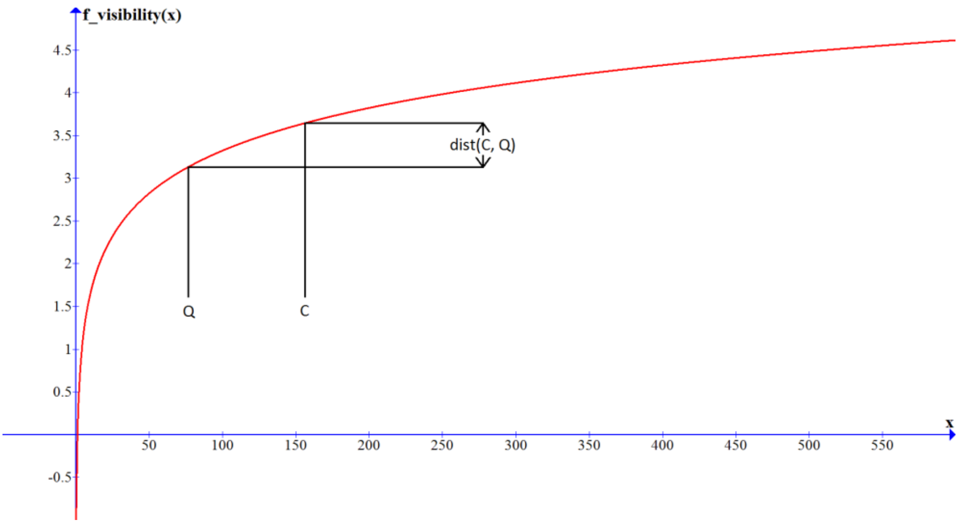

Figure 7: Visibility distance function

4.2.2.3 Similarity Function: Speed Limit

Like many of the other attributes, the speed limit attributes have a decision dependent similarity function (as described in section 4.1.2.2). As mentioned in section 4.2.2, it is assumed that lower recommended speed limit always means that the driving conditions are worse (assuming all other attributes stay the same). Because of this, open cases are relevant to look at even if the recommended speed limit in the query is higher than in the case. The speed limit similarity should therefore be 1 in this case. Similarly, closed cases are relevant to look at even if the recommended speed limit in the query is lower than in the case. The speed limit similarity should therefore be 1 even in this case.

If none of the above criteria can be used to set the speed limit similarity to 1, the similarity function for speed limit uses the distance function in Equation 16.

$$dist_{speed\ limit}(C,Q) = \frac{|C-Q|}{40}$$

Equation 16: Speed limit distance function

This equation gives a linear similarity function. If the recommended speed limit in the query is the same as in the case, the similarity is 1. If the difference in speed limit between the query and the case is 20 km/h, the similarity is 0.5. If the difference in speed limit is more than 40 km/h, the similarity between the query and the case is 0.

4.2.3 Decision Rule

The decision rule for this model is the same as the decision rule for the first CBR-model and is described in section 4.1.3. The arguments for choosing this decision rule for the first model are also applicable to this model. In addition, the two different CBR-models will be compared with regard to the performance of the similarity functions and attribute sets of the two models. To be able to properly compare the similarity functions the decision rules need to be the same for both models in order to be able to rule out different decision rules as the reason for differences in the results.

4.3 Sensor Based Uncertainty Model

Most of the attributes used in the two CBR-models presented in this chapter are measured directly by sensors. The rest of the attributes are calculated from the values of these attributes. When using sensors to get attribute values, there will always be some uncertainty in the values. Sensors are not perfect but do always have error margins. The sensors that are used to collect data for this project are sensors on the weather stations of the NPRA. There are a number of different sensor models that are used on these weather stations, as presented in the NPRA's Håndbok R613 (Statens Vegvesen, 2014b). All of the sensors are however required to meet some requirements set up by the NPRA regarding (among other things) the error margins of the sensors (Statens Vegvesen, 2009). The error margins for the sensors measuring the attributes in this project are as stated in Table 6.

Attribute type	Error margin
Wind speed	± 0.5 m/s at wind speeds below 5 m/s ± 10% otherwise
Wind direction	± 5 °
Friction	not specified
Temperature	± 0.1 °C in the range -10 - +10 °C ± 0.2 °C otherwise
Precipitation	± 0.1 mm/h

Table 6: Error margins for sensors

One way in which these errors in the sensor values can be handled in combination with a CBR-system is to query the CBR-system multiple times and each time use different values from within the error margin of the sensors. By assuming that the probability distribution for the real value of an attribute is uniform within the error margin of the sensor this can be done by randomly selecting attribute values within the error margin. As there are no error margin specified for friction sensors, these values can be left out of the random selection and thereby be assumed to be without error. By running a Monte Carlo simulation (as described in section 2.3) of the 3 steps below, it is possible to get a probability distribution for the different decisions.

1. Select attribute values for all cases in the case-base randomly within the error margins of the sensors.
2. Select attribute values for the query randomly within the error margins of the sensors.
3. Run the CBR-system to get a suggested decision.

If the simulation gives the result closed every time, uncertainty in the sensors can be ruled out as the reason for the decision. If the simulation however gives the result closed in only 60% of the runs it might be that the conditions are right on the edge of forcing the road to be closed and the operators can be informed of that when making a decision. This method for dealing with sensor uncertainty can be used together with any of the two CBR-models presented in this chapter.

5 Experiments and Results

This chapter will describe the testing that has been performed on the CBR-models presented in chapter 4. First there will be a presentation about which tests that have been performed, with which data the tests have been performed and how the testing has been performed. After that, the results from the tests will be presented.

5.1 Experimental Plan

The objective of the testing of the models presented in chapter 4 is to compare the performance of the different CBR-models to each other. The objective is also to compare the performance of the CBR-models to the performance of the solution used today by the winter road maintenance operators at Dovrefjell, as presented in section 3.2. Both of the CBR-models in this project are tested both as pure CBR-systems and in combination with the method for handling sensor uncertainty presented in section 4.3.

5.1.1 Performance Measure

To be able to test the CBR-models there has to be some way of measuring the performance of the models. As this project is aimed at developing a decision support system for winter road maintenance operators when deciding whether a road should be kept open or being closed, the performance measure for the testing has been selected with help from Stian Brenden Maskinservice AS. For this project it is not optimal to only measure the number of correct decisions made by the system. Because mountain roads are open most of the time, a system that always suggests keeping the road open would be very good according to a performance measure like that. Instead a performance measure has been chosen that values convoy and closed cases higher as there are fewer of them. The performance measure used in the tests is the average of:

- The proportion of open queries that are classified correctly.
- The proportion of convoy queries that are classified correctly.
- The proportion of closed queries that are classified correctly.

The formula for this performance measure is shown in Equation 17.

$$performance = \frac{\frac{\#correct\_open}{\#total\_open} + \frac{\#correct\_convoy}{\#total\_convoy} + \frac{\#correct\_closed}{\#total\_closed}}{3}$$

Equation 17: Performance measure

This performance measure works for testing of the CBR-models as well as the mobile application used by the operators today. The performance measure does not however work for testing CBR-models in combination with the method for handling sensor uncertainty (presented in section 4.3). In this case, a query will not be answered by a decision but instead by a probability for each of the 3 possible decisions. A query can for example be answered by:

- Open: 0.45
- Convoy: 0.45
- Closed: 0.10

As the system does not return a single decision it cannot be determined if the system is correct or not. To handle this, a system using sensor uncertainty handling is said to be partially correct and gets a score equal to the probability for the correct decision for each query. Using the probabilities in the example above, if open is the correct decision the system will score 0.45 for this query. #correct_open will therefore be increased with 0.45 whereas #total_open will be increased by 1.

5.1.2 Data Sets

The data that are used for testing the CBR-models are data that has been collected at the NPRA's weather stations at Avsjøen, Fokstugu and Hjerkinn. The data have been collected between November 2011 and March 2014. During this time, the road over Dovrefjell has been closed or has been subject to convoy driving 14 times. The test data are collected in the timespan around these events starting a couple of days before the road was closed and ending a couple of days after the road was opened again. The data that are available for the time between the closing/convoy events are missing some of the attributes used in the CBR-models and can therefore not be used in the testing.

The data consists of a total of 767 data points/cases. These are divided into two data sets, one training set (383 cases) and one test set (384 cases). The cases are divided so that both data sets have the same proportion of open, convoy and closed cases. Apart from that, the cases are divided randomly. The data in the two data sets can be seen in appendix A and appendix B . In addition to being used in the testing, the training data set has also been used for finding attribute weights in the similarity functions for the CBR-models, which is described in section 4.1.2.1 and 4.2.2.1. Because of this the data in the training data set cannot be used as queries in the testing.

5.2 Experimental Setup

In order to be able to test the CBR-models they have to be implemented. Here the implementation of the CBR-models is described. The use of the data sets to create case-bases and query sets is also described.

5.2.1 CBR Implementation

There are many CBR-frameworks available that can be used to implement a CBR-system. For this project, jCOLIBRI ('jCOLIBRI', 2016) and myCBR ('myCBR', 2016) were considered. Both of these frameworks were introduced and recommended during master classes at IDI, NTNU in the autumn of 2015. In the end, none of these frameworks were chosen. Instead it was chosen to implement the CBR-models from scratch. There are mainly two reasons for this decision:

- The CBR-models in this project are difficult to represent in any of the two systems that were considered. This is due to the complex similarity functions where many of the attribute similarity functions are decision dependent, as described in section 4.1.2.2.
- This project focuses on the retrieve step of the CBR-cycle. This makes many of the features of the CBR-frameworks unnecessary for this project.

For the implementation of the CBR-models, Java was chosen as the programming language. The following things have been implemented for this project:

- The CBR-models presented in chapter 4 including:
  - Case reading from CSV-file
  - Similarity functions
  - Visibility estimation and recommended speed limit calculation
- An evolutionary algorithm for finding optimal attribute weights for the attribute similarity functions of the CBR-models.
- Final similarity functions, including attribute weights found by the evolutionary algorithm.
- The formula for suggesting if the road should be closed used in the mobile application that is used by the winter road maintenance operators today.
- The test procedure for testing the performance of the CBR-models and the mobile application, as described in this chapter.

5.2.2 Case-Base and Queries

For testing the CBR-models, a case-base and a set of test queries are needed. The test queries cannot be from the training data set as that data set has been used to find the weights for the similarity functions. The cases in the training data set can however be used in the case-base. The cases in the test data set can be used in either the case-base or the set of test queries.

To form a set of test queries, half of the test data set (192 cases) is randomly selected. The rest of the test data set together with the training data set form the case-base. This means that the size of the case-base is 575 (383 + 192) and that the size of the query set is 192. By running the CBR-system for the test queries, a performance value (Equation 17) can be calculated for the CBR-models. During the testing, the process of randomly selecting a query set and a case-base is repeated many times and an average performance over the query sets are calculated.

The mobile application that the CBR-models are being compared to does not make use of a case-base in the decision making. The application is however still tested with the same query sets as the CBR-models as to make the results comparable.

5.3 Experimental Results

Two tests have been performed for the CBR-models. In the first test the CBR-models (without sensor uncertainty handling) have been compared to the mobile application. The test has been performed using 1000 randomly generated query sets (as described in section 5.2.2) and the average performance of the different models have been calculated.

The formula used in the mobile application requires friction data to be able to come up with a decision. In the test data used in this project, friction data are missing for about 75% of the cases. This means that the mobile application can only be used in 25% of the cases. Because of this, the performance of the mobile application is tested in two ways:

- Using the same query sets as for the CBR-models. If the formula is not able to come up with a decision because of missing attributes this is interpreted as a wrong decision.
- Using the same query sets as for the CBR-models but ignoring queries where needed attributes are missing. The performance is calculated based only on the cases that can be handled by the application.

The results of the first test are presented in Figure 8.

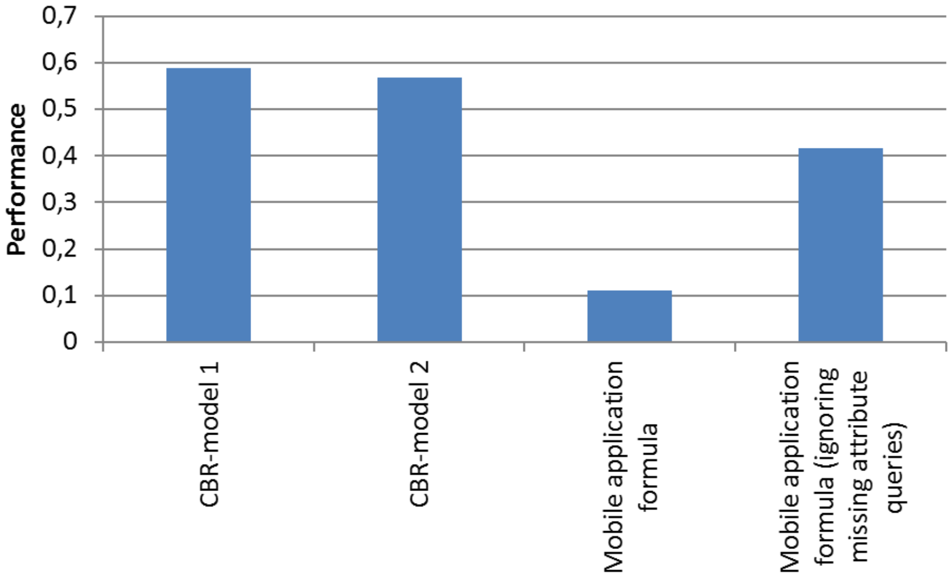

Figure 8: Test results, CBR compared to mobile application

The performance of the different models is calculated as the average of:

- The proportion of open queries that are classified correctly
- The proportion of convoy queries that are classified correctly
- The proportion of closed queries that are classified correctly

This means that the results of the test can be divided into three categories:

- Performance on queries where the correct decision are open
- Performance on queries where the correct decision are convoy
- Performance on queries where the correct decision are closed

This is presented in Figure 9.

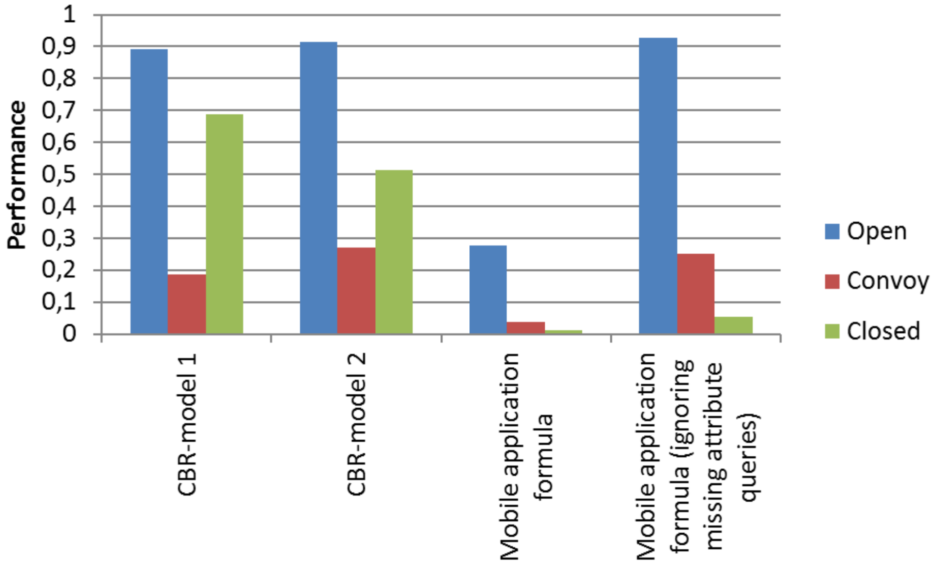

Figure 9: Test results for different decisions

In the second test, the performance of the CBR-models has been compared to the performance of using the CBR-models in combination with the sensor uncertainty handling method presented in section 4.3. In this test the Monte Carlo simulation of the sensor uncertainty model has been running the CBR-system 100 times per query. A total of 100 random query sets have been used in this test. The results from this test are presented in Figure 10.

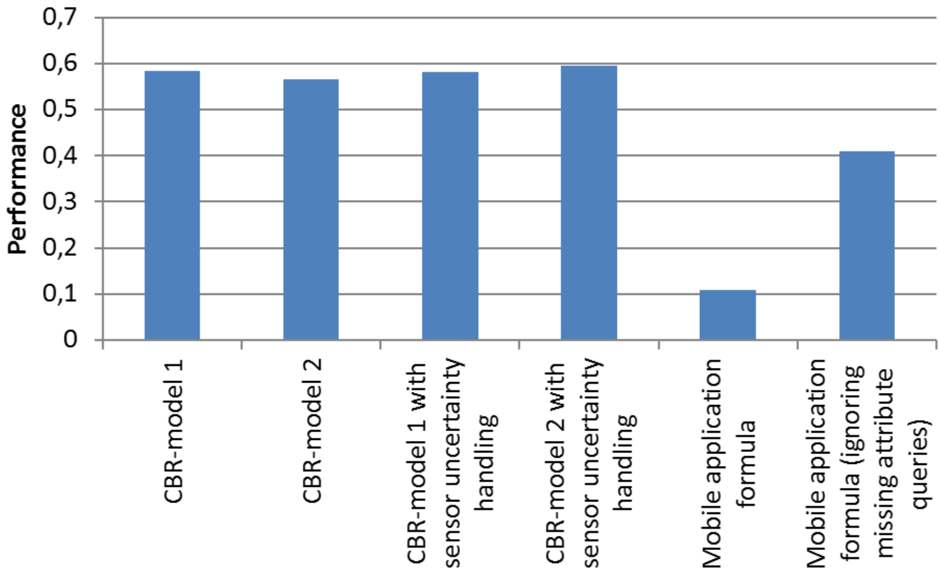

Figure 10: Test results for CBR with sensor uncertainty handling

6 Evaluation and Conclusion

In this chapter the results from the testing are evaluated and the use of the CBR-models for other stretches of roads is discussed. The results of the project are evaluated against the goal of the project and finally some ideas for future work are presented.

6.1 Evaluation

The results for the first test (comparing the CBR-models to the mobile application) are presented in Figure 8. The results for the two CBR-models are quite similar while the results for the mobile application are lower than for the CBR-models. Comparing the two results for the mobile application, the test that is ignoring queries with missing attributes gives about four times as high performance as the test using all queries. This is expected as the mobile application is not able to handle queries with missing attributes and only about 25% of the test data contains all attributes that the mobile application needs. Even in the test ignoring missing attribute queries, the mobile application has a lower performance than the CBR-models. The CBR-models have not been tested using only queries that are not missing any attributes. Because friction (that is missing in about 75% of the test data) is used as an attribute in both CBR-models, it is possible that the CBR-models could perform even better if tested using only queries containing all attributes.

Figure 9 shows the proportion of open, convoy and closed cases that the different systems were able to make correct decisions for. Comparing the CBR-models to the test for the mobile application ignoring missing attribute queries, the performance for open cases are about the same. All three systems are able to identify about 90% of all open cases. For convoy cases the second CBR-model is about as good as the mobile application while the first CBR-model is slightly worse. The big difference between the CBR-models and the mobile application is in recognizing closed cases. The CBR-models are able to make correct decisions for 50-70% of closed cases while the mobile application is only able to make correct decisions for about 5% of closed cases. According to Jo Skjermo (who is one of the authors of a report presenting the mobile application (Engen et al., 2015)) the application uses minimum criteria for when the road needs to be closed. This means that the application only suggests closing the road if it is completely sure of it. This explains why the performance of the mobile application differs that much between open and closed cases.

In the second test, using the CBR-models in combination with sensor uncertainty handling was tested. The results for this test are presented in Figure 10. The results show that the performances of both of the CBR-models are about the same both with and without sensor uncertainty handling. This is expected. It can be assumed that using sensor uncertainty handling; it is equally likely for the CBR-models to switch decision to the correct one as it is to switch decision from the correct one. Because of this, the performance is expected to be the same with and without sensor uncertainty handling. The purpose of the sensor uncertainty handling is not to increase the performance according to the performance measure in Equation 17. The purpose is to give the user of the system an indication of the uncertainty of the decisions that the system are suggesting.

6.2 Discussion

For a machine learning system (like CBR) to work, it needs previously observed data to learn from. For this project, the data is collected from the NPRA's weather stations at Fokstugu, Avsjøen and Hjerkinn. In the testing of the models, the decisions taken by the models need to be compared to the correct decision for the situations to see if the decisions of the models are correct. This means that the correct decisions for all cases in the test data are needed. In the domain of this project it is usually not possible to determine what would have been the correct decision in a previous situation. Even after a period where the road was closed it is not possible to determine if it was correct to close the road. For this project it has therefore been assumed that the correct decisions in previous cases are the decisions that were taken by the operators. If the operators choose to close the road it is assumed that it was the correct decision to close the road. The models in this project is therefore not trained and tested to see if they can make the correct decisions but are instead trained and tested for making the same decisions as the operators have done (which is assumed to be the correct decisions). Because of this, the CBR-models might be useful for transferring experience to new operators.

In the design process of the CBR-models in this project, attributes to use in the models have been chosen based on documentation as well as statements from the operators on which attributes that are important. In the search for attribute weights for the similarity functions, some of the attributes are given very low or zero weight. This means that these attributes are not actually used by the CBR-models and could have been left out. Some of the attribute types have very different weights at different weather stations. For example, the friction attribute at Fokstugu has a weight of 0.122 while the friction attribute at Avsjøen has a weight of 0.001. This suggests that even if an attribute type has a low weight at one weather station, the attribute type could not have been left out entirely.

The attributes used in the CBR-models are chosen based on documentation not specific to Dovrefjell but general to roads over mountain passes. This suggests that it is likely that the attributes used in this project can be used in CBR-systems for other roads as well. The similarity functions in this project are developed in cooperation with the operators at Dovrefjell. These similarity functions might not be applicable for other roads. If the CBR-models are going to be used at another road, it can be useful to test the similarity functions for that road or let the operators for that road verify the similarity functions. The attribute weights used in the similarity functions are specific to each weather station at Dovrefjell. These need to be chosen specifically for each road that the CBR-models are going to be used for.

6.3 Conclusion

The research questions for this project were:

- How can a CBR-system for winter road operation make use of domain specific knowledge?
- How can uncertainty in sensor values be handled in a CBR-system?

In this project two CBR-models have been developed. The first model makes use of domain knowledge in the form of:

- The choice of attributes that have been used for representing cases and queries.
- The similarity function used for comparing cases and queries. The similarity function has been developed by help from Stian Brenden Maskinservice AS and does therefore include domain knowledge of the operators.
- The choice of decision rule to use in the CBR-system. The decision rule used, Nearest Neighbour, is a general decision rule that does not in itself contain any domain knowledge. However, the reasons for choosing this decision rule add some domain knowledge to the model, as it is an informed choice.

In the second model in this project additional domain knowledge if used in the form of equations and formulas for estimating/calculating visibility and speed limit recommendation.

As to the second research question, this project presents a method for handling uncertainty in sensor values. This method can be used in combination with any CBR-system that uses sensor values as attributes. When used in combination with the CBR-models of this project, the performance of CBR-models is the same with and without the sensor uncertainty handling. The method does however give the operators more information about the situation. Because of this the method is suitable for decision support systems where the output of the system is interpreted by humans. It might not be of any use in an automatic system where the system makes the final decision on this own.

The goal of this project was to implement a CBR-system for winter road operation at Dovrefjell that is able to recognize when the road needs to be closed. The two CBR-models that have been develop and implemented in this project have been tested against the mobile application used by the operators today. The test results show that both of the suggested CBR-models are better than the mobile application at recognizing when the road needs to be closed.

6.4 Future Work

This project has been focusing on the retrieve and reuse steps of the CBR-cycle. For the CBR-models of this project to be used in a CBR-based decision support system, further research into the revise and retain steps are needed. For a CBR-system to be able to improve over time, the retain step is essential. Challenges with this step can be both CBR related and organizational related. From a CBR point of view, the retain step needs to be developed so that cases that are relevant for future use are retained while cases that are not relevant are not. From an organizational point of view, procedures for how the decisions made by the operators are going to be entered into the CBR-system are needed.

In this project, the focus has been on developing CBR-models for use in a decision support system. If the models developed in this project are going to be used in a decision support system a user interface for the models needs to be developed. In this project, the CBR-models have only been tested with regard to the performance measure in Equation 17. By developing a user interface for the models, user testing can be conducted for the system. This can reveal if the CBR-models are actually useful for the operators.

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Appendix

A. Training Data Set

Wind speed Fokstugu	Wind direction Fokstugu	Precipitation Fokstugu	Friction Fokstugu	Temperature Fokstugu	Wind speed Avsjoen	Wind direction Avsjoen	Precipitation Avsjoen	Friction Avsjoen	Temperature Avsjoen	Wind speed Hjerkinn	Wind direction Hjerkinn	Precipitation Hjerkinn	Temperature Hjerkinn	Decision
7,75	190	0,00		1,00	7,48	235	0,00		0,17	2,97	179	0,00	-1,58	OPEN
7,32	181	0,00		1,37	4,95	256	0,00		0,83	1,58	256	0,00	-1,85	OPEN
5,40	169	0,00		1,05	4,47	249	0,00		1,30	1,73	136	0,00	-1,87	OPEN
13,27	142	0,43		-0,22	14,13	177	1,03		-0,23	8,22	181	0,02	-1,47	OPEN
12,70	148	0,45		0,15	16,88	177	0,95		-0,25	10,32	194	0,00	-0,80	OPEN
10,77	151	0,00		2,30	12,67	189	0,00		2,05	10,52	201	0,00	0,33	OPEN
12,58	154	0,00		2,78	13,43	188	0,00		2,35	7,68	204	0,00	0,72	OPEN
12,68	148	0,00		3,17	15,23	189	0,00		2,88	6,02	190	0,00	1,38	OPEN
11,15	140	0,00		3,73	16,93	190	0,00		3,12	7,90	174	0,00	1,65	OPEN
10,02	145	0,00		3,97	17,37	189	0,00		3,25	9,78	175	0,00	1,87	OPEN
10,83	149	0,00		4,10	17,12	192	0,00		3,22	12,42	177	0,00	1,80	OPEN
11,65	158	0,00		4,10	14,23	185	0,03		3,42	9,77	185	0,00	2,07	OPEN
12,38	157	0,30		3,85	15,55	185	3,70		3,05	12,28	177	2,00	1,77	OPEN
6,60	231	0,00		-0,60	6,85	236	0,05		-1,38	6,77	250	0,00	-3,28	OPEN
6,52	212	0,00		-1,27	2,75	250	0,00		-3,10	6,65	241	0,00	-4,75	OPEN
5,42	199	0,00		-1,22	5,10	244	0,00		-2,60	6,88	240	0,00	-4,83	OPEN
5,47	195	0,00		-1,17	7,17	226	0,00		-2,17	4,92	244	0,08	-4,22	OPEN
7,15	203	0,02		-1,15	8,55	223	0,00		-1,75	5,42	229	1,32	-3,80	OPEN
5,68	209	0,00		-1,23	7,07	231	0,37		-2,05	7,83	248	1,57	-4,12	OPEN
2,93	186	0,00		-2,45	5,78	229	0,32		-2,90	5,93	224	0,00	-5,18	OPEN
8,30	150	0,00		-1,02	10,87	225	0,00		-1,30	8,88	212	0,00	-3,07	OPEN
11,32	144	0,48		-0,98	15,50	191	0,77		-1,57	8,25	204	0,00	-2,65	OPEN
13,07	151	0,38		-0,37	17,65	193	1,60		-1,07	6,88	182	0,02	-2,45	OPEN
15,13	158	1,03		-0,25	15,62	192	3,22		-0,90	9,43	169	0,45	-1,92	OPEN
14,28	156	0,55		-0,08	15,00	192	2,93		-0,72	9,87	165	0,12	-1,92	OPEN
14,35	160	0,63		0,27	14,93	193	1,97		-0,28	9,85	166	0,25	-1,50	OPEN
13,73	158	0,45		0,30	15,82	191	1,95		-0,23	8,78	171	0,15	-1,15	OPEN
15,23	152	0,73		0,12	18,07	186	3,30		-0,42	5,62	214	0,18	-1,13	OPEN
13,17	156	3,80		-0,02	14,28	175	10,43		-0,48	14,73	153	7,43	-1,63	OPEN
11,25	168	4,85		-0,42	14,27	189	11,40		-1,23	12,72	169	6,42	-2,20	OPEN
6,20	161	0,00		-1,63	12,38	199	0,02		-3,48	6,47	190	0,00	-3,48	OPEN
10,22	163	0,02		-2,02	14,22	197	0,05		-3,70	7,23	189	0,00	-3,77	OPEN
11,87	165	3,95		-2,30	16,55	202	3,42		-3,62	9,60	188	0,52	-3,88	OPEN
4,82	195	0,00		-4,93	7,55	230	0,00		-6,32	10,00	242	0,00	-7,48	OPEN
2,27	195	0,00		-5,35	6,93	241	0,17		-6,20	8,53	242	0,57	-7,95	OPEN
3,50	203	0,00		-5,60	4,70	249	0,10		-6,62	8,22	248	0,22	-8,12	OPEN
2,93	178	0,00		-5,33	5,02	247	0,43		-6,78	9,38	249	0,75	-7,80	OPEN
3,03	183	0,08		-6,78	4,43	259	0,33		-7,55	8,23	247	0,23	-8,80	OPEN
3,18	180	0,00		-6,25	4,80	255	0,00		-7,32	7,30	246	0,00	-8,82	OPEN
2,00	167	0,00		-6,02	3,83	265	0,00		-7,47	7,68	248	0,00	-8,28	OPEN
2,85	166	0,00		-6,20	5,70	231	0,00		-6,80	6,03	238	0,00	-8,60	OPEN
5,98	158	0,00		-7,10	2,40	255	0,00		-9,07	3,42	265	0,00	-10,17	OPEN
5,65	179	0,00		-6,43	2,65	241	0,00		-8,57	2,40	236	0,00	-10,13	OPEN
5,58	174	0,00		-5,83	2,32	168	0,00		-7,70	1,65	203	0,00	-8,55	OPEN
3,78	186	0,00		-6,17	4,18	234	0,00		-6,33	1,75	158	0,00	-8,50	OPEN
2,62	178	0,00		-6,27	8,45	220	0,00		-6,08	5,35	194	0,00	-7,38	OPEN
4,50	202	0,00	0,70	-3,17	4,42	249	0,55	0,30	-4,00	6,40	245	0,87	-5,93	OPEN
5,42	219	0,00	0,20	-5,25	3,62	251	0,00	0,70	-6,62	6,13	258	0,00	-7,40	OPEN
5,60	207	0,00	0,70	-5,95	4,05	258	0,00	0,60	-7,05	3,97	232	0,00	-8,92	OPEN
4,03	207	0,00	0,70	-6,23	3,55	250	0,00	0,60	-8,27	6,83	228	0,00	-9,15	OPEN
3,42	202	0,00	0,70	-6,15	6,60	245	0,00	0,70	-7,75	10,75	261	0,00	-8,17	OPEN
2,80	185	0,00	0,70	-5,23	4,33	257	0,00	0,70	-7,35	8,35	228	0,00	-7,97	OPEN
5,85	167	0,00	0,80	-5,42	1,93	274	0,00	0,60	-7,48	2,13	286	0,00	-8,72	OPEN
7,72	178	0,00	0,80	-4,10	8,68	240	0,00	0,60	-4,90	3,92	228	0,00	-7,08	OPEN
7,32	146	0,00	0,80	-3,63	5,63	231	0,00	0,40	-3,10	4,55	193	0,00	-5,48	OPEN
12,28	151	0,00	0,80	-3,42	15,90	186	0,02	0,30	-3,63	9,38	197	0,00	-4,77	OPEN
7,63	226	0,00	0,50	-1,18	8,95	235	1,80	0,40	-1,85	9,88	243	6,33	-3,88	OPEN
6,43	214	0,30	0,50	-2,17	9,07	230	3,15	0,80	-2,85	11,38	249	1,73	-4,72	OPEN
7,32	195	0,00	0,30	-1,48	8,85	230	0,03	0,80	-2,07	8,12	231	2,73	-4,27	OPEN
7,78	196	0,00	0,40	-1,28	13,42	222	0,43	0,80	-1,88	8,23	226	2,03	-4,00	OPEN
3,45	226	0,00	0,60	-0,15	13,12	233	0,00	0,30	-0,90	12,07	241	0,00	-3,17	OPEN
9,17	190	0,00	0,70	0,97	17,48	228	0,00	0,20	-0,12	14,68	234	0,02	-2,45	OPEN
12,20	160	1,90	0,80	-0,02	5,97	234	0,20	0,10	0,65	10,47	213	0,80	-1,12	OPEN
11,10	171	0,28	0,80	0,12	6,42	232	0,20	0,10	0,95	10,25	201	0,98	-0,90	OPEN

13,30	179	0,42	0,80	1,83	17,32	213	2,85	0,10	1,75	10,85	205	1,93	0,20	OPEN
13,92	216	1,42	0,20	0,00	16,90	225	2,88	0,10	-0,63					CLOSED
11,02	250	0,00	0,20	-1,80	7,05	249	2,32	0,60	-2,52	16,50	289	8,42	-4,37	CLOSED
8,93	241	0,00	0,20	-2,33	6,47	246	1,60	0,70	-3,43	15,12	288	1,38	-5,38	OPEN
9,58	244	0,00	0,20	-2,17	6,17	241	0,00		-3,78	11,77	284	0,17	-4,93	OPEN
6,78	241	0,02	0,20	-1,90	6,33	241	0,00	0,70	-3,40	11,02	278	0,00	-4,60	OPEN
5,82	231	2,12	0,20	-2,03	6,27	241	0,00	0,70	-3,23	12,33	272	0,00	-4,07	OPEN
9,18	236	0,00	0,20	-1,73	8,45	223	0,00	0,60	-3,52	13,40	275	0,00	-4,38	OPEN
6,70	211	0,00	0,20	-2,00	7,07	223	0,00	0,60	-3,90	7,27	238	0,00	-4,90	OPEN
3,23	193	0,00	0,30	-1,53	3,87	229	0,00	0,40	-3,73	7,03	232	0,08	-4,32	OPEN
8,73	168	0,72	0,30	-0,07	2,02	151	4,42	0,50	-3,52	3,63	142	4,98	-4,87	OPEN
10,87	180	0,12	0,40	2,80	8,55	249	0,27	0,30	1,45	11,45	229	0,73	-0,33	OPEN
10,50	186	0,03	0,70	3,48	12,97	233	2,78	0,60	3,43	12,27	221	2,75	0,85	OPEN
10,70	199	0,02	0,70	3,75	12,33	240	2,65	0,60	3,20	10,58	221	1,73	0,95	CLOSED
7,20	212	0,08	0,70	3,48	12,22	232	3,75	0,60	2,83	10,17	215	4,27	0,83	CLOSED
6,52	216	0,12	0,70	3,35	10,77	225	6,37	0,70	2,58	7,98	222	4,30	0,82	CLOSED
9,33	226	1,00	0,70	3,15	11,80	224	2,68	0,60	2,27	11,20	241	0,87	0,90	OPEN
10,50	232	0,90	0,20	0,30	8,10	242	3,93	0,80	-0,50	13,78	269	3,33	-1,98	OPEN
7,67	240	33,82	0,20	-2,65	6,20	238	4,05	0,80	-2,82	8,15	280	2,03	-4,12	OPEN
8,37	235	0,00	0,20	-4,20	8,15	235	0,22	0,80	-4,48	11,13	259	0,87	-6,18	OPEN
8,12	238	3,95		-4,53	8,68	232	2,93	0,80	-4,95	10,45	260	8,88	-6,65	OPEN
4,75	204	0,03	0,10	-2,65	4,33	252	0,15	0,80	-3,23	7,03	265	2,72	-4,93	OPEN
3,22	179	0,00	0,10	-5,88	5,10	250	0,00	0,40	-6,12	7,37	255	0,00	-7,70	OPEN
3,92	187	0,00	0,10	-6,30	4,33	261	0,00	0,30	-6,67	7,40	240	0,00	-8,42	OPEN
6,62	193	0,00	0,10	-4,05	11,48	222	0,00	0,50	-4,90	8,77	232	0,53	-6,92	OPEN
7,65	198	0,00	0,10	-4,07	12,50	220	0,00	0,40	-4,83	9,05	226	0,12	-6,80	OPEN
7,50	215	0,00	0,10	-3,52	8,53	230	0,58	0,30	-4,33	9,45	241	3,35	-6,57	OPEN
6,35	217	0,00	0,10	-3,47	8,83	229	0,90	0,20	-4,23	11,92	239	4,58	-6,35	OPEN
7,30	216	0,00	0,10	-3,02	7,78	231	0,75	0,20	-3,90	8,78	245	1,72	-5,87	OPEN
7,52	190	0,00	0,10	-3,32	9,87	226	4,25	0,30	-4,03	7,83	229	12,12	-5,98	OPEN
6,82	174	1,67	0,10	-2,63	6,03	234	5,22	0,80	-3,33	6,40	205	11,70	-5,17	OPEN
5,10	192	0,80	0,10	-2,80	4,90	252	8,92	0,80	-3,77	4,42	252	4,58	-5,27	OPEN
5,38	268	0,00	0,10	-4,93	2,82	269	0,00	0,80	-5,22	6,58	286	0,00	-8,05	OPEN
3,78	248	0,00	0,10	-6,80	4,23	248	0,00	0,80	-6,67	6,67	320	0,63	-8,97	OPEN
4,05	221	0,03	0,10	-7,50	4,15	250	0,02	0,80	-7,07	8,90	299	0,07	-9,82	OPEN
4,83	248	0,28	0,10	-7,03	5,10	255	1,02	0,60	-6,97	11,32	290	1,15	-8,50	OPEN
6,78	285	0,48	0,10	-6,73	4,67	280	2,42	0,60	-6,52	13,03	312	4,77	-9,10	CLOSED
7,10	282	0,85	0,10	-6,47	4,58	282	3,35	0,40	-6,33	11,67	313	9,25	-8,85	CLOSED
5,48	278	1,85	0,10	-6,58	4,13	276	1,00	0,50	-5,92	13,50	313	8,63	-8,47	CLOSED
7,28	281	4,65	0,10	-6,35	3,67	286	7,15	0,80	-6,50	13,95	310	8,35	-8,62	CLOSED
8,05	298	0,95	0,10	-6,38	4,43	277	5,05	0,80	-6,67	13,92	307	4,07	-8,72	CLOSED
6,35	284	2,78	0,10	-6,55	4,92	270	6,70	0,80	-6,88	10,93	308	5,60	-8,75	CLOSED
5,68	269	0,97	0,10	-6,42	3,37	259	5,10	0,80	-6,77	10,35	304	2,23	-8,30	CLOSED
4,65	286	2,25	0,10	-6,18	3,65	259	8,45	0,80	-6,53	9,45	305	9,33	-8,17	CLOSED
4,17	265	0,68	0,10	-5,70	3,45	273	2,45	0,80	-5,67	11,67	313	5,45	-7,50	CLOSED
6,63	301	1,58	0,10	-5,25	4,42	266	3,83	0,80	-5,58	12,17	325	4,18	-7,35	CLOSED
7,18	312	2,27	0,10	-5,23	4,05	288	3,97	0,80	-5,85	12,85	318	3,20	-7,52	CLOSED
8,02	306	1,62	0,10	-4,93	6,40	314	5,33	0,80	-5,32	17,83	323	0,00	-7,07	CLOSED
9,00	321	1,40	0,10	-4,60	5,40	303	2,10	0,80	-5,20	16,50	334	5,60	-7,00	CLOSED
8,22	322	0,00	0,20	-5,67	5,72	323	2,35	0,80	-5,93	16,92	327	5,45	-8,18	CLOSED
5,50	332	0,00	0,20	-5,60	4,20	299	0,50	0,80	-6,30	14,70	325	6,80	-7,90	CLOSED
1,30	131	0,00		-13,98	0,28	180	0,00		-27,68	0,25	215	0,00	-19,27	OPEN
1,18	153	0,00		-14,80	0,82	195	0,00		-26,27	1,00	263	0,00	-21,42	OPEN
1,38	143	0,00		-16,75	0,68	151	0,00		-24,87	1,13	252	0,00	-22,42	OPEN
2,52	126	0,00		-11,33	0,87	136	0,00		-22,25	0,68	211	0,00	-20,08	OPEN
4,37	158	0,00		-8,95	1,18	94	0,00		-21,62	1,18	159	0,00	-17,60	OPEN
6,43	154	0,00		-8,57	1,55	68	0,00		-21,20	1,88	138	0,00	-16,60	OPEN
8,98	135	0,00		-8,87	2,22	54	0,00		-19,67	2,25	135	0,00	-18,33	OPEN
9,42	138	0,00		-8,45	1,55	72	0,00		-19,33	1,88	146	0,00	-17,77	OPEN
8,62	141	0,00		-8,92	1,07	122	0,00		-19,08	1,58	139	0,00	-17,17	OPEN
9,07	139	0,00		-9,60	0,83	140	0,00		-19,30	2,03	182	0,00	-18,55	OPEN
12,35	138	0,42		-10,98	1,27	150	0,00		-19,00	1,58	204	0,00	-18,60	OPEN
13,77	137	1,77		-11,30	2,02	114	0,00		-15,08	2,08	169	0,00	-16,72	OPEN
13,13	141	2,12		-11,02	3,50	269	0,02		-10,67	2,40	256	0,00	-16,48	OPEN

13,80	142	5,40		-11,03	6,50	263	0,08		-9,95	5,55	216	0,00	-12,00	OPEN
18,77	136	7,42		-11,43	16,38	184	6553,50		-11,05	5,53	212	0,00	-11,53	OPEN
14,52	125	5,00		-11,97	11,75	199	6553,50		-10,65	4,25	223	0,00	-11,30	CLOSED
18,50	135	3,57		-11,80	13,73	189	6553,50		-10,87	4,53	241	0,00	-11,97	CLOSED
17,83	138	2,78		-11,73	15,35	186	6553,50		-10,82	7,45	222	0,00	-11,55	CLOSED
16,92	137	4,48		-11,55	14,63	186	6553,50		-10,55	8,40	221	0,00	-11,57	CLOSED
13,67	146	4,60		-11,38	13,12	189	6553,50		-9,88	7,55	229	0,07	-11,28	CLOSED
12,10	148	1,60		-11,15	11,97	185	6553,50		-9,40	4,60	237	0,00	-10,87	CLOSED
15,10	144	2,77		-10,92	11,55	199	6553,50		-9,12	5,37	237	0,00	-10,78	CLOSED
13,63	128	4,85		-10,95	11,13	199	6553,50		-9,32	5,28	265	0,00	-11,57	CLOSED
14,83	140	14,52		-10,85	6,40	255	6553,50		-9,17	6,05	205	0,00	-10,10	CONVOY
17,30	139	7,17		-10,53	6,50	230	6553,50		-9,72	6,40	197	0,02	-9,65	CONVOY
16,97	139	9,23		-10,47	8,78	217	6553,50		-9,77	8,75	189	0,12	-9,48	CONVOY
14,43	142	7,32		-10,15	12,28	227	6553,50		-9,55	14,90	200	0,40	-10,37	CONVOY
14,38	143	6,82		-9,83	9,62	237	6553,50		-9,12	12,72	192	0,03	-9,92	CONVOY
15,65	142	13,20		-9,80	12,25	208	6553,50		-9,47	6,67	185	0,03	-9,62	CONVOY
14,50	150	5,28		-9,53	19,60	183	6553,50		-9,57	9,80	187	0,08	-10,12	CLOSED
10,75	165	1,50		-8,97	12,62	224	6553,50		-9,07	9,35	186	0,42	-9,98	CLOSED
10,93	153	1,80		-8,45	5,12	241	6553,50		-8,52	5,43	152	0,23	-9,53	CLOSED
7,72	161	0,70		-8,43	3,32	217	6553,50		-8,13	11,57	168	4,68	-9,92	CLOSED
6,17	172	0,63		-8,23	3,58	233	6553,50		-8,20	7,00	160	1,07	-9,87	CLOSED
5,70	170	0,23		-8,12	4,63	228	6553,50		-8,17	10,15	162	2,07	-9,90	CLOSED
5,22	168	0,43		-8,13	4,87	258	6553,50		-8,08	8,12	159	1,08	-9,83	CLOSED
6,90	163	0,62		-8,20	4,53	255	6553,50		-7,88	8,28	160	1,77	-9,65	CLOSED
5,67	162	0,17		-8,12	5,25	265	6553,50		-7,88	8,95	164	1,47	-9,63	CLOSED
10,68	156	0,78		-8,17	17,47	179	6553,50		-8,78	4,92	251	0,07	-9,60	CLOSED
10,58	155	0,30		-8,27	4,00	236	6553,50		-7,82	4,08	147	0,00	-9,07	CLOSED
10,55	149	0,08		-7,98	10,52	188	6553,50		-8,12	2,00	171	0,00	-9,12	OPEN
10,15	149	0,28		-7,90	14,12	179	6553,50		-8,27	2,37	241	0,00	-9,12	OPEN
11,23	155	0,12		-7,90	9,70	191	6553,50		-8,05	5,15	183	0,00	-9,47	OPEN
10,47	156	0,03		-7,98	7,35	187	6553,50		-8,03	7,63	152	0,00	-9,17	OPEN
4,22	194	0,00		-5,92	8,73	209	6553,50		-5,77	6,12	275	0,00	-7,08	OPEN
3,53	198	0,05		-4,63	8,70	242	6553,50		-4,88	9,08	237	0,25	-5,82	OPEN
5,15	220	1,63		-3,12	8,45	231	6553,50		-3,45	11,77	261	2,17	-4,65	OPEN
4,93	245	0,43		-2,60	5,88	253	6553,50		-2,60	10,12	292	3,38	-4,30	OPEN
7,65	302	0,00		-6,57	5,57	305	6553,50		-6,22	17,48	314	0,97	-8,75	CONVOY
6,93	302	0,35		-5,40	5,30	305	6553,50		-4,78	16,48	319	4,27	-7,28	CONVOY
6,97	319	0,10		-4,57	6,88	175	6553,50		-5,18	17,45	334	2,03	-7,22	CONVOY
2,55	140	0,00		-5,32	4,42	93	6553,50		-5,82	11,78	338	2,50	-7,68	CONVOY
3,92	130	0,00		-5,25	1,57	114	6553,50		-6,00	8,55	336	0,00	-7,33	OPEN
4,00	289	0,00		-5,25	2,12	127	6553,50		-5,78	6,03	315	0,43	-7,45	OPEN
1,78	216	0,00		-5,37	2,07	99	6553,50		-5,97	6,28	323	0,00	-7,55	OPEN
2,92	171	0,00		-5,10	3,45	301	6553,50		-4,90	5,10	294	0,85	-7,00	OPEN
2,70	296	0,00		-4,95	3,10	298	6553,50		-5,38	6,98	298	0,05	-7,55	OPEN
4,73	280	0,00		-5,07	2,58	304	6553,50		-4,97	6,67	329	0,08	-7,20	OPEN
3,02	289	0,00		-5,20	4,57	210	6553,50		-5,07	6,15	309	0,03	-7,20	OPEN
1,38	218	0,00		-5,70	2,22	281	6553,50		-6,42	3,07	264	0,00	-8,07	OPEN
2,77	236	0,00		-6,22	1,93	252	6553,50		-6,82	1,50	261	0,00	-8,12	OPEN
3,90	225	0,00		-6,62	1,52	267	6553,50		-6,57	4,20	327	0,00	-8,12	OPEN
3,08	217	0,00		-6,80	1,62	239	6553,50		-7,87	2,15	246	0,00	-7,90	OPEN
2,25	182	0,00		-7,22	3,85	256	6553,50		-7,43	3,32	242	0,00	-8,68	OPEN
3,00	189	0,00		-6,25	3,90	261	6553,50		-7,33	6,12	241	0,00	-8,00	OPEN
7,07	294	0,00	0,20	-5,30	6,08	298	0,03	0,70	-4,33	17,10	317	0,10	-6,80	OPEN
9,92	294	0,00	0,10	-4,96	4,40	299	0,00	0,30	-3,93	15,27	320	0,02	-6,45	OPEN
5,72	298	0,00	0,10	-4,72	3,78	312	0,03	0,70	-3,68	12,56	325	0,32	-6,18	OPEN
6,14	229	0,00	0,20	-4,18	3,82	261	0,00	0,10	-3,30	15,03	320	0,00	-6,05	OPEN
6,07	233	0,08	0,20	-3,93	6,40	230	0,00	0,20	-3,00	9,20	310	0,00	-6,00	OPEN
4,26	252	0,00	0,80	-2,38	4,75	128	0,00	0,80	-0,93	3,32	266	0,00	-4,98	OPEN
8,23	266	0,03	0,80	-3,27	4,20	278	0,00	0,80	-1,93	5,32	298	0,00	-4,32	OPEN
9,30	272	0,00	0,40	-3,60	4,67	241	0,00	0,80	-2,70	4,98	305	0,00	-4,28	OPEN
			0,50		5,07	230	0,00	0,80	-3,67	5,43	286	0,00	-5,18	OPEN
5,24	213	0,00	0,70	-4,02	5,83	254	0,00	0,80	-4,13	6,83	235	0,00	-6,00	OPEN
5,88	244	0,02	0,80	-4,62	5,45	239	0,00	0,80	-4,65	8,42	250	0,00	-6,48	OPEN
4,28	217	0,47	0,80	-5,40	9,15	222	0,02	0,80	-5,58	9,15	238	0,00	-7,12	OPEN

4,15	178	0,85	0,10	-5,30	7,53	236	0,43	0,80	-5,57	8,25	244	0,50	-7,33	OPEN
4,80	215	1,72	0,10	-4,30	5,88	245	1,12	0,80	-5,27	7,90	248	1,50	-6,80	OPEN
7,50	193	0,50	0,10	-3,60	6,57	233	0,25	0,80	-4,45	6,64	191	0,08	-6,00	OPEN
3,47	204	0,13	0,10	-1,92	13,87	228	1,40	0,80	-2,98	11,07	228	0,90	-4,23	OPEN
7,56	213	0,00	0,10	-0,74	10,88	233	0,00	0,80	-1,87	13,52	246	0,13	-3,45	OPEN
11,45	232	0,00	0,10	-0,23	9,83	236	0,23	0,80	-1,37	10,67	245	0,32	-3,37	OPEN
11,62	239	11,25	0,10	-0,53	10,98	236	0,70	0,80	-1,07	14,00	264	0,23	-2,63	OPEN
11,37	253	0,33	0,10	-1,98	8,23	260	0,13	0,80	-1,78	15,95	294	1,13	-4,08	OPEN
			0,10		10,70	236	1,62	0,80	-5,00					OPEN
			0,10		8,85	241	1,62	0,80	-4,88					OPEN
10,72	260	1,40	0,10	-4,98	9,52	248	2,48	0,80	-4,82	18,40	286	2,26	-6,72	CONVOY
10,67	254	1,02	0,10	-5,08	9,15	242	2,27	0,80	-5,20	16,18	285	3,50	-6,73	CONVOY
9,95	259	1,13	0,10	-4,82	7,03	242	1,93	0,80	-4,97	16,60	291	2,20	-6,60	CONVOY
			0,20		5,05	276	0,87	0,80	-4,72					CONVOY
10,80	274	0,10	0,20	-6,45	6,85	278	0,00	0,80	-5,53	13,28	300	0,42	-8,02	CONVOY
7,90	257	0,02	0,20	-7,17	6,15	274	0,00	0,80	-6,63	13,88	307	0,02	-9,62	CLOSED
7,15	264	0,12	0,20	-7,25	5,95	275	0,02	0,80	-6,63	13,50	309	0,10	-9,50	CLOSED
8,00	256	0,00	0,20	-7,60	6,67	273	0,00	0,80	-6,82	15,64	300	0,00	-9,92	CLOSED
4,33	198	0,20	0,20	-7,68	4,58	257	0,78	0,80	-7,75	10,02	286	1,14	-7,58	CLOSED
5,83	262	0,00	0,10	-6,55	5,25	294	0,28	0,80	-5,87	14,12	320	2,15	-7,53	OPEN
3,72	205	0,04	0,10	-6,24	1,98	248	0,00	0,80	-6,13	4,87	308	0,05	-8,00	OPEN
4,07	232	0,10	0,10	-5,18	3,98	241	0,00	0,80	-4,80	5,77	301	0,00	-7,00	OPEN
3,85	247	0,15	0,10	-5,02	6,48	226	0,00	0,80	-4,92	2,77	261	0,00	-5,65	OPEN
5,40	260	0,00	0,20	-5,10	6,38	230	0,00	0,80	-4,35	6,03	269	0,00	-5,90	OPEN
4,73	235	0,00	0,80	-5,40	5,55	239	0,00	0,80	-4,98	7,06	235	0,00	-6,58	OPEN
4,08	238	0,03	0,80	-5,33	4,85	244	0,00	0,80	-5,50	10,55	251	0,00	-7,50	OPEN
3,80	188	0,02	0,80	-5,63	4,80	248	0,05	0,80	-6,30	7,45	224	0,00	-8,03	OPEN
7,76	196	0,18	0,60	-4,80	7,48	244	0,70	0,80	-5,98	6,37	239	0,78	-7,43	OPEN
4,98	215	0,00		4,50	14,57	215	0,00		4,58	9,92	221	0,00	2,48	OPEN
5,22	242	0,00		4,70	13,97	214	0,00		4,87	8,07	217	0,00	1,98	OPEN
5,55	249	0,00		4,93	12,92	218	0,00		5,30	4,53	215	0,00	4,05	OPEN
6,25	253	0,00		5,12	10,16	211	0,00		4,97	2,62	142	0,00	2,72	OPEN
4,66	241	0,00		5,14	10,33	210	0,00		4,68	5,73	218	0,00	2,93	OPEN
3,20	198	0,00		5,35	11,78	224	0,00		5,00	5,72	254	0,00	4,88	OPEN
4,66	224	0,00		4,86	10,98	226	0,00		5,00	13,63	283	0,00	4,98	OPEN
9,23	222	0,00		4,47	11,20	227	0,00		4,48	16,52	284	0,00	4,42	OPEN
11,32	237	0,00		4,63	11,26	219	0,00		4,27	19,07	279	0,00	4,13	OPEN
6,38	237	0,00		3,57	6,20	237	0,00		3,10	14,78	270	0,00	2,37	OPEN
7,37	251	0,03		1,68	6,36	243	0,02		1,72	7,72	285	0,05	-0,38	OPEN
8,32	259	0,02		-0,82	7,94	240	0,02		-0,48	14,58	276	0,00	-1,23	OPEN
6,02	234	0,47		-2,05	8,18	224	0,10		-2,00	6,68	260	0,02	-3,82	OPEN
5,98	230	0,02		-2,27	8,04	235	2,40		-2,07	8,88	280	0,22	-3,97	OPEN
6,25	218	0,10		-2,60	8,48	224	0,12		-2,80	9,32	252	0,05	-4,30	OPEN
8,93	246	0,07		-2,98	8,52	261	1,00		-3,20	11,98	286	1,00	-5,27	OPEN
8,12	256	0,07		-3,53	5,75	262	0,77		-3,67	11,77	299	0,77	-5,87	OPEN
10,17	268	0,03		-4,63	7,33	264	0,18		-4,58	12,57	292	0,37	-6,95	CLOSED
7,65	276	0,10		-4,62	6,78	249	0,07		-4,68	10,95	283	0,08	-6,30	CLOSED
10,00	263	0,05		-4,55	6,30	244	0,02		-4,48	14,60	289	0,00	-6,30	CLOSED
10,47	264	0,05		-4,33	6,77	251	0,00		-4,30	13,70	294	0,03	-6,00	CLOSED
10,20	266	0,04		-4,36	5,82	243	0,02		-4,25	13,83	296	0,00	-5,60	CLOSED
8,55	255	0,05		-4,12	5,95	261	0,00		-3,58	13,33	300	0,02	-5,53	CLOSED
11,43	260	0,05		-4,00	6,53	237	0,02		-3,45	15,22	290	0,15	-4,85	OPEN
9,15	259	0,02		-3,70	5,23	237	0,00		-2,83	11,17	292	0,10	-4,38	OPEN
7,07	252	0,02		-3,00	3,73	247	0,13		-2,83	9,77	299	0,73	-4,48	OPEN
4,65	247	0,63		-2,32	2,60	254	0,02		-2,40	10,03	311	0,07	-4,23	OPEN
4,12	217	0,00		-4,06	2,22	220	0,00		-5,07	2,33	220	0,00	-6,28	OPEN
4,88	249	0,00		-3,63	3,15	276	0,00		-4,55	3,38	249	0,00	-4,75	OPEN
8,17	232	0,17		-0,88	7,68	227	0,00		-0,84	10,68	264	0,13	-2,33	OPEN
8,15	256	32,98		-2,73	7,60	265	0,10		-2,75	14,33	296	34,72	-5,25	OPEN
8,65	241	53,60		-4,10	5,70	236	0,22		-4,37	13,73	283	16,70	-6,00	OPEN
9,83	272	21,07		-4,08	8,25	258	0,17		-4,08	14,87	293	42,82	-6,23	OPEN
11,36	271	3,70		-4,54	7,53	264	0,12		-4,28	15,18	293	6,87	-6,62	OPEN
10,53	269	9,93		-4,63	5,94	251	0,06		-4,66	14,22	293	2,76	-6,50	CLOSED
9,28	255	2,60		-4,05	8,30	242	0,26		-4,06	11,15	298	5,63	-5,35	CLOSED

7,78	309	1,97		-3,08	4,47	258	0,30		-3,23	14,82	317	2,93	-5,40	CLOSED
5,93	297	0,00		-3,70	4,45	235	0,27		-4,20	10,60	323	0,58	-6,12	CLOSED
6,70	300	0,00		-4,18	1,80	256	0,03		-4,33	10,27	324	0,05	-6,23	CLOSED
6,72	281	0,00		-4,45	6,20	294	0,00		-4,00	11,07	308	0,00	-6,45	OPEN
3,87	241	0,00		-5,22	7,17	222	0,00		-5,18	5,52	250	0,00	-6,78	OPEN
6,92	271	0,00		-5,67	5,23	238	0,00		-5,23	4,28	226	0,00	-6,52	OPEN
13,58	136	0,44		-3,48	3,06	44	0,00		-6,12	4,57	152	0,02	-8,33	OPEN
15,53	137	0,80		-3,36	9,42	139	0,02		-2,83	3,72	213	0,00	-8,03	OPEN
19,77	143	0,70		-3,25	8,98	105	0,00		-3,38	2,87	206	0,00	-6,95	OPEN
13,58	142	0,00		-3,03	12,72	163	0,00		-2,32	4,57	143	0,00	-4,63	CLOSED
11,83	139	0,00		-2,48	3,60	153	0,00		-1,80	6,58	161	0,00	-4,78	CLOSED
10,08	149	0,10		-1,33	8,42	171	0,00		-0,65	2,27	181	0,00	-5,50	OPEN
14,42	125	0,68		-0,60	4,40	93	0,03		-2,27	3,40	120	0,06	-4,94	OPEN
17,90	142	1,45		-0,45	20,76	169	0,02		1,06	1,63	173	0,00	-3,37	OPEN
11,95	164	0,02		1,47	15,12	193	0,00		1,54	12,60	173	0,00	-0,33	OPEN
8,40	147	0,00		-1,47	8,77	174	0,00		-1,33	9,38	155	0,00	-3,57	OPEN
10,72	152	0,00		-1,48	11,33	188	0,00		-1,42	14,73	159	0,02	-3,38	OPEN
8,00	138	0,00		-5,38	2,33	267	0,00		-6,33					OPEN
2,27	244	0,00		-5,35	2,05	180	0,00		-10,55					OPEN
2,40	99	0,00		-4,88	2,08	124	0,00		-5,12					OPEN
5,47	172	0,00		-3,82	2,20	250	0,00		-3,67					OPEN
9,67	154	0,00		-3,78	5,58	216	0,00		-3,00					OPEN
8,88	153	0,00		-3,62	4,25	216	0,00		-3,07					OPEN
7,94	133	0,00		-2,96	9,12	173	0,00		-2,40					OPEN
13,12	124	0,73		-3,35	15,80	167	0,20		-3,15					OPEN
15,17	149	0,18		-3,45	19,52	170	0,00		-3,03					CLOSED
12,53	147	0,22		-3,13	16,32	181	0,00		-2,08					CLOSED
13,50	139	0,10		-2,02	18,47	178	0,00		-1,28					CLOSED
12,95	137	0,10		-1,50	16,56	180	0,20		-1,14					CLOSED
11,80	163	0,02		-0,44	17,22	196	0,00		-0,65					CLOSED
12,93	159	0,00		-0,83	15,75	190	0,00		-0,75					CLOSED
14,34	154	0,02		-0,94	13,93	192	0,00		-0,92					CLOSED
11,67	147	0,00		-0,53	16,62	201	0,00		-0,83					CLOSED
12,30	148	0,00		-0,70	13,24	200	0,16		-0,94					CLOSED
14,25	146	0,07		-1,27	17,43	192	0,00		-1,30					OPEN
13,30	152	0,02		-1,78	16,22	185	0,00		-1,65					OPEN
11,53	152	0,10		-1,70	15,32	181	0,02		-1,65					OPEN
9,72	150	0,00		-1,33	12,46	188	0,00		-1,08					OPEN
3,10	207	0,00		-2,15	2,85	230	0,00		-1,15					OPEN
7,92	132	0,25		-2,28	1,58	31	0,00		-3,48					OPEN
10,60	132	0,00		-2,70	2,42	104	0,00		-3,45					OPEN
7,86	149	0,00		-2,70	7,15	179	0,00		-2,67					OPEN
7,00	134	0,00		-1,75	6,85	184	0,00		-1,47					OPEN
16,40	138	0,28		-1,83	10,42	154	0,98		-1,56					OPEN
14,20	144	0,06		-1,76	13,95	172	0,04		-1,50					CLOSED
9,24	157	0,00		-1,58	10,13	186	0,00		-1,37					CLOSED
10,00	147	0,00		-1,42	10,35	174	0,00		-1,43					OPEN
7,70	143	0,00		-1,78	4,85	173	0,00		-1,33					OPEN
7,36	146	0,00		-1,84	4,95	174	0,00		-1,77					OPEN
8,13	145	0,00		-1,58	6,45	199	0,00		-1,23					OPEN
6,33	163	0,00		-2,07	3,06	221	0,00		-1,68					OPEN
9,98	141	0,00		-2,26	2,68	269	0,00		-1,96					OPEN
6,83	139	0,00		-1,13	1,33	173	0,00		-3,33					OPEN
1,20	244	0,00		-1,75	1,72	164	0,00		-3,95					OPEN
4,77	178	0,00		-1,67	1,85	261	0,00		-5,92					OPEN
3,23	154	0,00		-11,03	3,32	40	0,02		-13,72					OPEN
5,00	195	0,00		-11,62	2,16	66	0,00		-14,20					OPEN
4,35	195	0,00		-10,92	1,24	82	0,00		-14,13					OPEN
3,84	199	0,00		-11,46	0,20	117	0,00		-14,33					OPEN
1,98	210	0,02		-11,33	0,44	119	0,00		-13,94					OPEN
3,50	74	0,00		-11,77	1,58	53	0,00		-13,48					OPEN
9,63	122	0,22		-11,35	4,40	99	0,00		-12,52					OPEN
10,00	149	0,56		-11,04	4,86	87	0,00		-10,02					OPEN
15,27	144	0,50		-11,25	3,55	260	0,00		-10,28					CLOSED

17,72	145	0,58		-11,88	2,90	235	0,00		-10,62					CLOSED
18,22	139	0,04		-12,14	6,32	248	0,00		-11,12					CLOSED
18,35	139	0,10		-12,32	5,32	247	0,00		-11,15					CLOSED
16,10	146	0,06		-11,96	2,40	196	0,00		-10,64					CLOSED
15,24	134	0,02		-12,07	3,82	229	0,00		-10,63					OPEN
16,13	134	0,05		-12,07	4,25	235	0,00		-10,70					OPEN
					2,90	286	0,00		-11,50					CLOSED
					4,45	197	0,00		-11,25					CLOSED
					3,70	219	0,00		-11,60					CONVOY
					5,60	54	0,00		-13,43					CONVOY
					4,70	53	0,00		-13,25					CONVOY
					2,88	95	0,00		-12,70					CONVOY
					19,26	177	0,02		-12,78					CONVOY
					18,00	184	0,00		-13,03					CONVOY
					15,25	181	0,00		-13,15					CONVOY
					16,70	185	0,00		-12,43					CONVOY
					10,46	182	0,00		-12,60					CONVOY
					9,80	195	0,00		-12,48					OPEN
					6,73	256	0,00		-12,10					OPEN
					2,67	269	0,00		-11,93					OPEN
					8,58	192	0,00		-12,63					OPEN
					3,92	261	0,00		-11,85					OPEN
					0,10	174	0,00		-22,37	1,17	314	0,00	-20,35	OPEN
					0,00	181	0,00		-23,82	0,77	332	0,00	-21,52	OPEN
					0,00	220	0,00		-25,12	0,00	229	0,00	-21,63	OPEN
					0,00	249	0,00		-24,50	1,12	263	0,00	-22,97	OPEN
					0,75	82	0,00		-22,36	1,14	235	0,00	-23,38	OPEN
					0,13	188	0,00		-18,98	0,78	276	0,00	-20,35	OPEN
					2,46	72	0,00		-11,54	1,16	307	0,00	-17,42	OPEN
					4,72	49	0,00		-10,20	1,28	317	0,00	-16,58	OPEN
					6,60	260	0,03		-7,65	5,38	154	0,00	-9,87	OPEN
					12,40	194	0,12		-7,78	3,62	165	0,00	-9,44	OPEN
					18,30	179	0,23		-7,63	4,10	191	0,00	-9,33	OPEN
					13,97	181	0,22		-7,77	5,45	171	0,00	-9,35	OPEN
					17,70	170	0,08		-7,66	6,40	215	0,00	-9,42	CLOSED
					13,56	175	0,32		-7,74	7,42	233	0,07	-9,40	CLOSED
					12,90	174	0,05		-7,47	5,36	207	0,00	-8,96	CLOSED
					8,76	206	0,00		-6,82	4,17	188	0,00	-8,32	CLOSED
					5,32	239	0,00		-6,46	1,84	201	0,00	-8,46	CLOSED
					2,04	94	0,00		-8,30	0,44	275	0,00	-11,76	OPEN
					2,04	52	0,00		-8,30	0,92	171	0,00	-11,54	OPEN
					2,18	48	0,00		-8,53	0,23	231	0,00	-11,48	OPEN
					2,52	50	0,00		-7,94	0,76	262	0,00	-10,58	OPEN
					3,92	55	0,00		-7,57	1,40	329	0,00	-10,40	OPEN
					1,33	34	0,00		-5,76	1,50	325	0,00	-9,12	OPEN
					1,24	168	0,00		-6,10	0,80	127	0,00	-7,88	OPEN
					1,65	243	0,00		-9,27	1,42	111	0,00	-9,26	OPEN
					1,57	160	0,00		-9,08	0,92	302	0,00	-9,12	OPEN
					3,68	159	0,00		-6,44	2,18	277	0,00	-8,38	OPEN
					2,72	266	0,00		-4,82	2,98	270	0,00	-8,55	OPEN
					8,12	198	0,00		-5,07	3,14	246	0,00	-8,80	OPEN
					7,24	260	0,00		-5,52	13,48	281	0,06	-7,74	OPEN
					7,70	241	0,06		-6,28	10,40	267	0,00	-8,26	OPEN
					7,20	265	0,34		-6,58	17,92	291	0,96	-9,28	OPEN
					6,80	242	0,00		-5,98	16,70	293	0,00	-9,74	CLOSED
					7,06	248	0,00		-5,76	11,88	288	0,00	-8,88	CLOSED
					7,50	237	0,00		-6,32	8,74	272	0,00	-8,08	OPEN
					7,68	235	0,00		-6,62	11,34	279	0,00	-8,66	OPEN
					10,44	222	0,00		-7,42	7,78	287	0,00	-8,92	OPEN
					9,72	223	0,00		-8,16	8,76	285	0,00	-9,54	OPEN
					4,20	264	0,00		-9,32	9,58	283	0,00	-10,02	OPEN
					4,30	252	0,00		-9,08	7,76	253	0,00	-10,26	OPEN
					3,48	249	0,00		-9,55	6,66	247	0,00	-10,46	OPEN

B. Test Data Set

Wind speed Fokstugu	Wind direction Fokstugu	Precipitation Fokstugu	Friction Fokstugu	Temperature Fokstugu	Wind speed Avsjoen	Wind direction Avsjoen	Precipitation Avsjoen	Friction Avsjoen	Temperature Avsjoen	Wind speed Hjerkinn	Wind direction Hjerkinn	Precipitation Hjerkinn	Temperature Hjerkinn	Decision
7,23	188	0,00		1,27	7,15	240	0,00		0,32	1,40	170	0,00	-1,83	OPEN
7,37	127	0,00		-0,45	7,15	191	0,00		-0,05	2,05	155	0,00	-1,97	OPEN
7,60	129	0,00		-0,67	8,27	188	0,00		-0,35	1,15	161	0,00	-2,40	OPEN
6,65	156	0,00		-0,40	3,07	257	0,00		0,00	0,92	214	0,00	-2,72	OPEN
11,55	143	0,22		-0,52	3,12	222	0,02		0,18	2,10	187	0,03	-2,90	OPEN
12,75	138	0,78		-0,45	9,17	162	0,28		-0,17	9,80	146	0,05	-1,63	OPEN
12,68	148	0,58		-0,05	15,65	178	0,47		-0,03	8,30	193	0,00	-1,13	OPEN
12,20	148	0,47		0,27	17,55	177	1,15		-0,53	7,17	201	0,00	-0,38	OPEN
11,73	148	0,03		0,80	14,90	183	0,02		0,08	4,47	220	0,00	-0,20	OPEN
10,87	148	0,00		1,32	14,97	188	0,00		1,07	4,10	211	0,00	0,10	OPEN
10,50	145	0,00		1,77	13,65	185	0,00		1,55	8,55	183	0,00	-0,13	OPEN
13,23	156	0,00		4,07	13,75	201	0,00		3,62	13,67	170	0,00	1,87	OPEN
13,57	159	0,00		3,95	13,65	194	0,00		3,50	7,02	187	0,00	1,85	OPEN
9,15	195	30,30		1,98	12,97	206	7,58		2,13	10,93	205	3,65	0,68	OPEN
5,48	234	0,00		-0,08	8,20	230	2,62		-0,90	12,10	257	1,08	-1,43	OPEN
6,03	225	0,00		-0,15	8,17	228	0,00		-0,77	8,93	250	0,00	-1,75	OPEN
5,10	222	0,00		-0,27	6,32	230	0,00		-1,02	7,42	248	0,00	-2,52	OPEN
7,50	201	0,00		-1,42	3,28	248	0,67		-2,77	6,77	236	0,33	-4,37	OPEN
3,90	222	0,00		-0,92	6,28	234	0,05		-1,97	7,45	235	0,55	-3,98	OPEN
4,53	228	0,00		-0,95	6,20	236	1,28		-2,50	8,42	242	2,72	-4,33	OPEN
4,63	222	0,05		-1,87	5,10	231	3,65		-3,27	7,05	237	2,50	-4,82	OPEN
4,37	211	0,00		-1,78	3,58	244	0,00		-2,73	5,37	240	0,50	-4,80	OPEN
5,13	190	0,00		-1,67	4,77	237	0,08		-2,45	4,70	229	2,43	-4,43	OPEN
5,72	167	1,23		-2,08	6,23	229	0,17		-2,12	6,22	210	4,47	-4,32	OPEN
8,42	151	0,10		-1,77	8,70	206	0,37		-2,10	6,67	191	0,32	-3,88	OPEN
7,82	148	0,00		-1,35	10,88	209	0,00		-1,37	6,58	213	0,02	-3,28	OPEN
5,73	154	0,00		-1,15	10,10	225	0,00		-1,48	8,72	217	0,00	-3,48	OPEN
9,77	143	0,00		-1,23	14,37	195	0,00		-1,47	8,28	203	0,00	-2,83	OPEN
11,58	151	0,00		-1,38	13,43	197	0,00		-1,23	8,88	190	0,00	-2,80	OPEN
11,48	145	0,08		-1,28	12,97	192	0,00		-1,47	10,48	198	0,00	-2,87	OPEN
11,42	147	0,08		-0,50	17,25	192	0,53		-1,17	9,30	190	0,00	-2,78	OPEN
12,63	159	0,00		0,82	15,05	196	0,30		0,27	9,70	171	0,00	-1,03	OPEN
14,03	158	1,08		0,28	15,72	178	5,03		-0,18	11,05	162	1,53	-1,00	OPEN
7,63	174	0,02		-1,28	10,60	207	0,77		-2,32	7,83	201	0,23	-2,83	OPEN
10,83	175	3,52		-2,32	14,38	216	9,23		-3,18	12,27	207	12,08	-4,32	CLOSED
8,72	229	29,12		-1,50	9,93	232	3,63		-2,55	11,72	244	2,43	-3,88	CLOSED
6,40	230	0,33		-2,43	9,45	228	0,65		-3,08	9,77	263	2,85	-4,03	CLOSED
7,62	241	1,10		-3,37	7,83	231	0,08		-4,13	8,83	257	0,27	-4,65	CLOSED
6,47	231	0,47		-4,10	5,60	236	0,08		-4,77	11,07	265	0,05	-5,52	CLOSED
6,58	238	0,00		-4,62	6,20	241	0,50		-5,35	10,15	260	1,35	-6,32	OPEN
3,87	201	0,00		-4,62	5,48	243	0,02		-5,70	10,63	260	0,00	-6,72	OPEN
4,17	210	0,00		-4,83	5,88	240	0,00		-6,43	10,82	252	0,00	-7,17	OPEN
5,77	216	0,00		-4,97	7,97	228	0,00		-6,03	7,72	244	0,10	-7,83	OPEN
1,92	208	0,00		-6,12	5,47	247	0,10		-6,48	10,02	251	0,27	-7,72	OPEN
4,23	204	0,03		-6,15	4,18	252	0,05		-6,55	8,22	232	0,37	-8,05	OPEN
3,20	201	0,02		-6,40	4,07	266	1,05		-6,88	6,32	265	0,18	-8,05	OPEN
3,07	191	0,00		-6,87	4,37	262	0,00		-7,12	7,17	247	0,05	-8,37	OPEN
3,07	168	0,03		-6,70	4,83	251	0,42		-7,45	7,45	244	0,18	-8,65	OPEN
3,65	163	0,00		-7,15	5,65	244	0,00		-7,03	3,00	235	0,00	-9,12	OPEN
2,72	188	0,00		-6,38	3,57	224	0,00		-6,52	2,38	206	0,00	-8,42	OPEN
3,38	200	0,00	0,70	-3,40	2,97	270	0,00	0,20	-3,93	6,50	240	0,40	-5,53	OPEN
3,27	214	0,05	0,40	-4,27	2,53	264	0,47	0,80	-4,87	6,57	244	0,03	-6,00	OPEN
4,27	219	0,00	0,10	-4,63	4,10	259	0,00	0,80	-4,92	5,23	267	0,08	-6,53	OPEN
3,78	194	0,00	0,70	-5,68	4,33	257	0,00	0,70	-7,03	6,85	246	0,00	-8,17	OPEN
5,42	200	0,00	0,70	-6,03	3,32	268	0,00	0,60	-7,05	4,32	217	0,00	-9,50	OPEN
4,08	207	0,00	0,70	-6,03	4,83	253	0,00	0,70	-8,15	5,98	241	0,00	-8,78	OPEN
3,02	189	0,00	0,60	-6,07	4,05	253	0,00	0,70	-7,92	7,82	243	0,00	-8,60	OPEN
4,95	166	0,00	0,80	-5,77	3,13	260	0,00	0,60	-6,30	5,32	257	0,00	-7,75	OPEN
6,62	171	0,00	0,80	-5,30	2,97	240	0,00	0,70	-6,65	3,98	230	0,00	-8,48	OPEN
5,58	161	0,00	0,80	-3,52	5,68	245	0,00	0,50	-4,25	5,97	242	0,00	-6,00	OPEN
8,63	144	0,00	0,80	-3,63	9,35	209	0,00	0,30	-3,22	3,95	155	0,02	-5,10	OPEN
10,75	158	0,00	0,80	-3,32	12,32	203	0,00	0,40	-3,70	5,92	183	0,00	-4,83	OPEN
12,15	151	0,00	0,80	-2,67	14,32	222	0,02	0,40	-2,38	5,35	218	0,00	-4,62	OPEN
10,58	173	0,00	0,80	-1,62	9,47	239	0,00	0,30	-1,58	8,68	221	0,00	-3,83	OPEN

10,05	158	0,00	0,80	-0,77	12,52	219	0,00	0,20	-0,97	9,70	215	0,02	-2,95	OPEN
7,52	155	0,50	0,80	-0,67	10,65	217	0,88	0,20	-0,80	9,05	210	1,55	-2,47	OPEN
6,13	205	0,02	0,70	-0,40	8,17	229	0,05	0,30	-0,52	7,67	224	0,03	-2,70	OPEN
3,57	203	0,02	0,60	-1,22	6,65	231	0,00	0,10	-1,60	6,93	248	0,00	-3,40	OPEN
7,60	211	0,03	0,60	-0,85	6,98	233	1,67	0,20	-1,60	5,57	231	1,18	-3,23	OPEN
5,23	216	0,03	0,50	-1,77	8,12	230	0,63	0,80	-2,32	11,18	247	0,63	-4,60	OPEN
5,83	214	0,05	0,50	-1,67	8,15	231	0,08	0,80	-2,45	8,93	236	0,82	-4,58	OPEN
7,65	203	0,05	0,40	-1,03	10,92	230	0,03	0,80	-1,52	8,85	226	2,67	-3,83	OPEN
7,58	200	0,00	0,50	-0,55	12,83	232	0,03	0,60	-1,20	11,48	224	0,00	-3,28	OPEN
9,43	184	0,00	0,80	0,52	11,95	235	0,00	0,20	0,33	14,75	220	0,03	-2,00	OPEN
11,52	166	0,07	0,80	1,63	13,48	220	0,12	0,10	1,78	8,95	216	0,22	-0,43	OPEN
1104,35	11114	1092,28	0,70	1047,75	1104,87	11117	1096,97	0,20	1046,72	2197,08	22009	2188,30	2092,73	CLOSED
								0,10		3286,78	32888	3276,75	3138,78	CLOSED
9,88	232	0,00	0,20	-2,43	7,08	244	0,00	0,70	-3,85	13,82	279	0,17	-5,27	OPEN
9,73	234	0,08	0,20	-1,53	5,58	235	0,00	0,70	-3,30	13,48	269	0,00	-4,02	OPEN
4,52	202	0,00	0,30	-2,05	7,92	230	0,00	0,40	-3,63	6,57	236	0,00	-4,93	OPEN
2,47	213	0,27	0,30	-1,47	2,32	94	1,88	0,30	-3,97	5,15	131	4,28	-5,10	OPEN
10,38	184	0,00	0,30	1,73	6,72	242	1,68	0,70	-1,28	7,85	188	1,92	-2,93	OPEN
10,83	177	0,03	0,70	2,82	12,80	234	1,83	0,10	3,30	11,43	223	1,78	0,58	OPEN
9,18	207	0,02	0,70	3,65	11,63	232	2,72	0,60	3,08	11,38	217	2,82	1,08	CLOSED
11,53	237	0,05	0,70	1,98	11,70	237	1,05	0,60	1,70	13,80	258	1,12	0,33	OPEN
8,43	234	5,32	0,20	-1,72	7,18	238	4,52	0,80	-2,25	10,57	268	3,28	-3,62	OPEN
7,05	229	9,62	0,20	-3,70	8,47	231	3,07	0,80	-3,92	9,92	267	2,77	-5,03	OPEN
		0,00	0,30	-4,60	5,70	253	5,80	0,80	-5,00	11,50	279	3,10	-6,60	OPEN
3,73	194	0,12	0,10	-2,08	4,22	267	1,00	0,80	-3,95	7,78	228	0,25	-4,82	OPEN
4,85	208	0,00	0,10	-1,88	3,67	252	0,22	0,80	-3,20	8,43	247	0,82	-4,65	OPEN
2,98	186	0,03	0,10	-3,68	4,23	256	0,03	0,80	-3,68	5,90	256	0,00	-4,92	OPEN
2,82	208	0,42	0,10	-3,52	3,35	251	0,48	0,80	-3,98	2,80	254	0,00	-5,32	OPEN
2,97	194	0,00	0,10	-4,17	3,38	247	0,35	0,80	-4,17	5,45	253	0,00	-5,53	OPEN
3,42	189	0,07	0,10	-4,63	6,98	228	0,57	0,50	-4,68	6,93	243	0,00	-6,65	OPEN
4,32	197	0,00	0,10	-5,02	4,15	257	0,22	0,40	-6,98	7,83	242	0,32	-7,88	OPEN
5,50	212	0,00	0,10	-4,28	3,45	239	2,03	0,20	-6,23	7,60	232	2,88	-7,45	OPEN
6,60	190	0,00	0,10	-4,18	9,03	225	0,20	0,30	-5,05	8,22	228	1,62	-6,92	OPEN
6,45	224	0,00	0,10	-3,27	7,57	231	1,43	0,70	-4,08	9,63	243	6,45	-6,23	OPEN
7,23	230	0,22	0,10	-3,08	7,43	236	1,08	0,50	-3,85	10,02	244	4,03	-6,22	OPEN
7,50	233	0,00	0,10	-2,98	7,02	237	1,10	0,40	-3,93	9,30	247	1,83	-5,92	OPEN
8,02	196	0,00	0,10	-3,17	7,47	231	0,48	0,20	-3,72	9,45	243	3,45	-5,92	OPEN
6,60	185	0,00	0,10	-3,17	11,00	225	2,68	0,40	-3,70	8,75	224	5,45	-5,77	OPEN
6,40	173	0,00	0,10	-3,17	11,15	223	1,37	0,20	-3,15	8,60	222	3,30	-5,37	OPEN
5,75	179	0,02	0,10	-2,93	8,45	224	0,33	0,60	-3,00	8,88	218	4,28	-5,15	OPEN
6,55	167	0,12	0,10	-2,52	7,27	228	1,73	0,70	-2,92	7,77	211	10,02	-5,15	OPEN
2,92	212	0,18	0,10	-3,55	4,80	254	4,22	0,80	-4,08	6,00	252	0,98	-5,40	OPEN
5,00	244	0,05	0,10	-3,87	3,15	268	1,35	0,80	-4,17	8,48	299	0,65	-6,35	OPEN
2,78	231	0,00	0,10	-7,63	4,60	245	0,00	0,80	-7,35	6,62	307	0,00	-10,47	OPEN
4,15	223	0,12	0,10	-7,55	3,87	245	0,00	0,60	-7,33	10,32	289	0,07	-9,03	OPEN
6,33	248	0,00	0,10	-6,75	4,75	255	0,02	0,30	-6,22	9,40	300	0,97	-8,43	OPEN
7,93	275	1,12	0,10	-6,58	5,12	286	0,57	0,50	-5,62	10,92	314	4,92	-8,75	OPEN
5,62	259	1,87	0,10	-6,57	3,55	249	8,32	0,80	-7,13	10,97	302	9,55	-8,80	CLOSED
4,07	244	1,75	0,10	-6,77	4,25	264	7,70	0,80	-6,65	8,92	306	5,33	-8,45	CLOSED
5,57	268	0,12	0,10	-6,77	3,97	303	1,70	0,80	-6,35	12,67	310	7,20	-8,40	CLOSED
2,90	236	0,47	0,10	-6,20	3,60	283	8,38	0,70	-6,25	10,98	313	6,65	-7,98	CLOSED
6,87	311	0,00	0,10	-4,88	3,88	277	4,37	0,80	-6,02	14,50	333	2,47	-7,65	CLOSED
8,35	315	1,27	0,10	-5,00	5,43	303	5,73	0,80	-5,67	17,10	327	10,08	-7,32	CLOSED
10,67	309	2,88	0,10	-5,33	5,47	311	6,18	0,80	-5,65	17,23	322	1,35	-7,48	CLOSED
9,85	310	0,08	0,10	-4,62	4,98	315	4,95	0,80	-5,18	18,75	322	5,05	-7,32	CLOSED
7,60	311	0,80	0,10	-4,78	5,02	312	3,45	0,80	-4,93	17,02	326	4,32	-6,92	CLOSED
9,08	317	0,35	0,10	-4,73	5,03	271	6,55	0,80	-5,10	16,03	327	8,15	-7,08	CLOSED
7,85	310	1,05	0,10	-4,40	5,08	267	4,47	0,80	-5,10	15,50	332	4,00	-6,85	CLOSED
8,34	300	1,06	0,10	-5,36	5,82	315	4,60	0,80	-4,96	17,16	324	1,60	-7,28	CLOSED
7,03	313	0,98	0,10	-5,42	5,75	315	5,22	0,80	-5,38	17,33	324	1,70	-7,70	CLOSED
0,92	98	0,00		-13,93	0,12	169	0,00		-27,98	1,00	258	0,00	-19,95	OPEN
0,62	173	0,00		-16,08	0,48	186	0,00		-27,25	0,50	144	0,00	-19,10	OPEN
0,93	164	0,00		-15,00	0,40	209	0,00		-26,95	1,12	266	0,00	-20,45	OPEN
0,87	157	0,00		-17,35	0,75	218	0,00		-24,63	0,85	259	0,00	-21,18	OPEN

1,32	109	0,00		-14,52	1,05	141	0,00		-22,58	0,97	230	0,00	-20,28	OPEN
7,38	128	0,00		-8,52	1,60	94	0,00		-20,82	2,23	137	0,00	-17,27	OPEN
15,48	140	5,58		-11,12	8,32	239	0,53		-10,48	7,02	185	0,00	-10,80	OPEN
16,93	141	5,80		-11,08	17,03	186	6553,50		-11,03	7,33	203	0,00	-10,92	OPEN
17,82	134	8,87		-11,85	13,07	199	6553,50		-11,43	8,43	211	0,00	-11,55	OPEN
8,57	169	7,70		-10,97	8,78	219	6553,50		-9,53	5,28	220	0,00	-10,87	CLOSED
11,33	148	2,73		-9,88	9,90	238	6553,50		-9,15	13,83	187	0,15	-10,03	CONVOY
15,43	143	6,45		-9,60	17,77	185	6553,50		-9,43	10,35	201	0,03	-9,98	CONVOY
12,12	157	1,85		-9,20	18,73	186	6553,50		-9,37	10,23	208	0,20	-10,10	CLOSED
12,32	158	5,83		-8,73	6,67	265	6553,50		-8,52	5,82	158	0,05	-9,55	CLOSED
9,92	153	1,82		-8,40	3,90	265	6553,50		-8,12	7,83	150	0,60	-9,77	CLOSED
4,33	185	1,10		-8,28	3,70	215	6553,50		-8,20	8,32	167	0,82	-9,85	CLOSED
4,92	163	0,87		-8,10	3,67	237	6553,50		-7,85	8,28	161	1,77	-9,63	CLOSED
7,68	149	1,57		-8,28	3,23	198	6553,50		-8,05	11,42	160	1,42	-9,92	CLOSED
9,50	151	2,62		-8,47	6,02	173	6553,50		-8,27	8,70	162	0,08	-9,83	CLOSED
8,83	160	0,50		-8,40	7,73	197	6553,50		-8,47	6,00	174	0,18	-9,80	CLOSED
8,28	161	1,53		-8,27	7,80	181	6553,50		-8,50	7,72	171	0,03	-9,83	CLOSED
12,60	146	3,28		-8,25	17,08	178	6553,50		-8,60	4,73	263	0,15	-9,43	CLOSED
11,13	152	1,63		-8,30	4,83	187	6553,50		-8,07	3,85	152	0,00	-9,10	CLOSED
10,85	151	0,13		-8,12	4,97	216	6553,50		-7,80	4,22	158	0,00	-9,03	OPEN
7,70	163	0,03		-8,03	5,45	242	6553,50		-8,02	7,25	192	0,03	-9,12	OPEN
5,27	167	0,02		-7,95	4,23	289	6553,50		-7,78	7,73	160	0,00	-9,30	OPEN
5,52	160	0,02		-7,87	5,18	248	6553,50		-7,92	9,62	162	0,10	-9,45	OPEN
6,27	151	0,00		-8,00	6,43	205	6553,50		-8,12	8,83	158	0,00	-9,65	OPEN
5,97	270	0,00		-5,43	2,78	262	6553,50		-4,92	6,75	307	0,00	-7,25	OPEN
2,75	211	0,00		-5,60	3,77	237	6553,50		-5,93	7,95	294	0,00	-7,68	OPEN
5,00	181	0,00		-5,73	4,87	243	6553,50		-6,07	7,90	287	0,00	-7,17	OPEN
3,07	213	0,03		-6,23	6,05	237	6553,50		-6,25	9,80	281	0,08	-7,18	OPEN
5,10	242	0,35		-5,93	6,38	254	6553,50		-5,88	10,47	269	0,08	-6,58	OPEN
4,67	241	0,13		-5,53	6,42	260	6553,50		-5,80	7,82	255	0,03	-5,35	OPEN
4,43	212	0,07		-4,37	12,28	221	6553,50		-4,43	11,18	235	0,10	-6,12	OPEN
5,43	231	1,25		-3,92	11,90	215	6553,50		-4,23	10,90	268	0,05	-4,75	OPEN
5,00	216	1,47		-3,50	11,00	223	6553,50		-3,83	15,18	271	0,88	-4,28	OPEN
5,77	238	3,53		-2,90	7,42	234	6553,50		-3,32	9,93	271	4,78	-4,55	OPEN
10,62	266	0,42		-2,95	6,12	251	6553,50		-3,63	11,67	294	4,47	-4,98	OPEN
11,85	270	12,63		-3,88	5,12	259	6553,50		-4,02	13,35	303	6,70	-5,87	OPEN
10,58	302	3,03		-4,98	5,03	304	6553,50		-4,82	20,03	322	8,92	-7,78	CLOSED
9,78	304	0,17		-6,87	5,03	286	6553,50		-6,32	15,32	315	1,95	-8,88	CLOSED
8,28	295	3,68		-6,82	2,50	279	6553,50		-6,87	13,12	312	7,83	-8,88	CLOSED
5,35	293	0,57		-6,75	1,30	156	6553,50		-7,30	9,80	317	3,27	-8,68	CLOSED
5,83	296	0,25		-6,13	3,80	292	6553,50		-6,68	13,12	318	1,22	-8,47	CLOSED
10,45	313	0,12		-7,03	6,68	314	6553,50		-7,20	17,65	320	3,53	-9,13	CONVOY
2,17	96	0,00		-5,63	3,60	66	6553,50		-6,02	14,12	335	0,38	-8,03	CONVOY
2,58	147	0,00		-5,38	2,30	143	6553,50		-6,23	12,43	335	0,08	-7,90	CONVOY
2,10	186	0,00		-6,03	1,97	186	6553,50		-5,95	9,58	338	0,27	-7,47	CONVOY
3,00	291	0,00		-5,63	2,48	258	6553,50		-6,13	7,87	316	0,00	-7,80	OPEN
4,72	297	0,00		-5,25	3,53	192	6553,50		-5,37	6,30	327	0,02	-7,17	OPEN
2,70	173	0,03		-4,87	4,85	63	6553,50		-5,92	8,45	330	0,00	-7,35	OPEN
3,02	141	0,13		-4,85	2,77	124	6553,50		-5,93	5,40	305	0,00	-8,13	OPEN
2,15	209	0,00		-7,00	3,53	256	6553,50		-7,33	1,05	125	0,00	-8,62	OPEN
2,93	175	0,00		-5,87	4,27	254	6553,50		-6,90	7,00	237	0,00	-7,57	OPEN
7,07	285	0,00	0,20	-5,80	5,55	271	0,00	0,20	-4,87	13,38	316	0,02	-7,40	OPEN
6,24	288	0,00	0,20	-5,72	6,10	287	0,00	0,40	-4,78	16,23	316	0,03	-7,17	OPEN
9,50	300	0,03	0,10	-5,30	4,98	303	0,03	0,70	-4,17	15,94	323	0,54	-6,84	OPEN
10,90	299	0,00	0,10	-5,50	4,62	301	0,00	0,50	-4,38	14,75	321	1,02	-6,88	OPEN
7,87	297	0,00	0,10	-4,80	3,85	293	0,00	0,40	-3,95	15,10	319	0,30	-6,40	OPEN
1,70	245	0,00	0,10	-4,52	4,48	274	0,00	0,80	-3,40	13,13	324	0,32	-5,95	OPEN
3,50	231	0,00	0,10	-4,40	5,12	319	0,00	0,20	-2,77	15,57	327	0,12	-5,87	OPEN
4,40	243	0,00	0,80	-3,20	3,32	186	0,00	0,10	-1,12					OPEN
			0,80		3,72	97	0,00	0,80	-0,15					OPEN
5,70	238	0,03	0,80	-5,10	6,12	227	0,00	0,80	-5,13	8,77	245	0,00	-6,85	OPEN
3,72	190	0,68	0,20	-5,70	6,45	227	0,93	0,80	-6,07	7,12	246	0,15	-7,28	OPEN
4,13	188	1,17	0,10	-4,82	7,42	243	1,27	0,80	-5,47	8,97	252	1,03	-7,12	OPEN
4,43	193	0,25	0,10	-2,45	9,65	227	0,55	0,80	-3,77	7,30	202	0,03	-5,63	OPEN

5,60	214	0,10	0,10	-1,60	13,75	226	0,20	0,80	-2,58	12,25	244	0,05	-3,68	OPEN
9,30	254	0,00	0,10	-3,20	9,48	246	2,48	0,80	-3,88	15,90	288	0,00	-6,10	OPEN
			0,10		9,90	243	4,27	0,80	-5,07					OPEN
9,22	263	3,20	0,10	-4,63	5,35	258	3,85	0,80	-4,55					CONVOY
11,00	276	15,90	0,10	-4,40	4,48	288	6,07	0,80	-4,63					CONVOY
			0,10		4,33	277	0,92	0,80	-4,43					CONVOY
8,93	275	0,12	0,20	-6,73	6,72	277	0,12	0,80	-6,42	14,15	298	0,15	-9,18	CONVOY
			0,20		5,05	259	0,00	0,80	-6,95	13,83	303	0,00	-9,55	CLOSED
4,96	216	0,62	0,20	-7,68	5,32	245	0,00	0,80	-7,65	11,62	294	0,00	-8,97	CLOSED
4,07	200	0,03	0,20	-7,92	4,80	245	0,00	0,80	-7,87	10,80	288	0,00	-8,50	CLOSED
5,10	291	0,00	0,10	-6,30	3,72	294	0,13	0,80	-6,00	7,88	314	0,03	-8,07	OPEN
3,57	219	0,03	0,10	-5,63	3,25	256	0,03	0,80	-5,68	6,85	313	0,02	-7,23	OPEN
5,00	233	0,00	0,30	-5,02	6,30	231	0,00	0,80	-4,28	6,13	254	0,00	-6,05	OPEN
5,57	249	0,00	0,60	-5,75	5,95	237	0,00	0,60	-4,70	7,00	265	0,00	-5,70	OPEN
3,83	202	0,00	0,80	-5,48	5,27	237	0,00	0,80	-6,10	8,62	242	0,00	-7,80	OPEN
3,70	182	0,00	0,80	-5,50	5,53	254	0,90	0,80	-6,37	5,10	223	0,00	-8,10	OPEN
			0,80		7,27	250	1,53	0,80	-6,57	3,06	217	0,12	-7,76	OPEN
6,60	194	0,05	0,60	-4,00	6,20	242	0,35	0,80	-5,32	7,05	233	0,77	-7,07	OPEN
5,00	228	0,00	0,70	-3,80	10,07	227	0,03	0,80	-4,48	6,37	236	0,18	-6,42	OPEN
5,18	242	0,00		5,08	13,72	210	0,00		5,30	4,32	257	0,00	4,47	OPEN
7,12	241	0,00		5,07	12,00	234	0,00		5,37	11,70	271	0,00	4,80	OPEN
7,00	231	0,00		3,83	6,62	238	0,00		3,73	13,82	277	0,00	3,38	OPEN
7,44	237	0,00		3,88	6,08	260	0,00		3,03	12,15	268	0,00	1,18	OPEN
5,45	235	0,02		-0,33	5,50	239	0,00		0,30	10,57	277	0,00	-1,03	OPEN
6,25	235	0,00		-1,68	9,14	239	0,00		-1,23	9,35	268	0,15	-3,42	OPEN
7,78	223	0,00		-2,45	8,92	237	0,12		-2,40	11,42	269	0,02	-4,02	OPEN
6,28	226	0,48		-2,72	11,33	230	0,82		-2,77	11,05	263	0,22	-4,42	OPEN
10,08	263	0,20		-3,97	8,77	257	0,10		-3,83	14,25	301	0,58	-6,22	CLOSED
9,44	252	0,74		-4,28	6,32	249	0,32		-4,33	15,05	293	0,10	-6,22	CLOSED
11,98	270	0,42		-4,32	6,55	252	0,00		-4,04	13,88	295	0,94	-6,52	CLOSED
9,05	263	0,03		-4,45	7,50	249	0,02		-4,10	14,92	296	0,14	-6,04	CLOSED
10,92	264	0,00		-3,72	6,17	245	0,00		-3,48	14,46	297	0,00	-5,37	CLOSED
11,40	260	0,05		-4,00	6,65	236	0,00		-3,88	13,97	288	0,00	-5,27	OPEN
7,20	264	0,10		-2,42	2,78	239	0,10		-2,57	7,67	306	0,17	-4,15	OPEN
4,43	258	0,07		-2,52	2,34	258	0,00		-3,10	12,27	319	0,02	-4,50	OPEN
4,48	218	0,00		-3,34	1,90	272	0,00		-4,50	8,03	319	0,00	-5,40	OPEN
2,93	226	0,00		-4,10	2,92	260	0,00		-5,00	0,97	174	0,00	-5,63	OPEN
5,22	255	0,00		-4,45	3,12	236	0,00		-4,12	10,15	334	0,00	-4,55	OPEN
9,05	247	0,45		-2,05	6,02	251	0,07		-1,52	10,85	286	0,00	-3,47	OPEN
8,82	245	18,25		-4,00	7,07	241	0,10		-3,98	14,50	284	4,33	-5,92	OPEN
7,50	247	3,16		-4,62	7,30	232	0,32		-4,72	13,46	280	0,78	-5,94	CLOSED
8,25	255	0,38		-3,55	4,84	264	0,13		-2,92	10,92	309	1,27	-4,97	CLOSED
8,32	309	0,63		-3,40	5,55	287	0,20		-4,00	13,60	333	0,62	-5,82	CLOSED
5,25	288	0,00		-4,27	2,55	300	0,00		-4,32	11,40	315	0,07	-6,60	CLOSED
4,42	278	0,00		-4,60	3,08	270	0,00		-4,38	11,30	322	0,00	-6,42	OPEN
5,25	266	0,00		-4,72	5,05	260	0,00		-4,07	14,00	315	0,00	-6,97	OPEN
3,97	215	0,00		-5,27	4,14	241	0,00		-4,74	8,90	311	0,00	-7,00	OPEN
4,27	219	0,00		-5,35	4,82	224	0,00		-5,28	2,38	216	0,00	-6,70	OPEN
3,40	202	0,00		-5,47	5,25	242	0,00		-5,48	7,25	259	0,00	-6,93	OPEN
9,38	131	0,08		-4,18	3,97	56	0,00		-6,52	3,08	144	0,00	-8,83	OPEN
15,80	139	0,08		-3,10	14,92	170	0,02		-2,58	3,45	245	0,00	-5,65	CLOSED
15,16	143	0,00		-3,22	15,96	167	0,00		-2,66	4,97	146	0,00	-4,98	CLOSED
5,68	145	0,00		-2,12	6,55	167	0,00		-1,28	5,34	163	0,00	-4,76	CLOSED
15,25	140	1,27		-0,42	15,60	161	0,03		1,05	5,43	33	0,12	-4,60	OPEN
13,86	146	0,60		-0,36	19,43	176	0,00		1,15	4,72	58	0,00	-1,63	OPEN
14,18	138	0,03		0,07	18,28	172	0,00		1,62	7,18	107	0,00	-0,58	OPEN
12,57	143	0,27		0,83	14,84	170	0,00		1,74	11,77	159	0,00	-0,12	OPEN
11,54	152	0,02		1,44	14,18	177	0,00		1,77	8,48	151	0,00	0,02	OPEN
7,85	166	0,00		0,50	13,62	202	0,00		0,87	9,42	205	0,00	-1,55	OPEN
6,72	171	0,00		-1,10	12,13	206	0,00		-0,62	8,22	197	0,00	-3,17	OPEN
9,08	148	0,00		-2,00	9,10	194	0,00		-1,57	5,12	191	0,00	-4,34	OPEN
8,07	145	0,43		-1,73	8,20	179	0,18		-1,43	10,48	157	0,03	-3,80	OPEN
2,88	159	0,00		-5,26	1,08	95	0,00		-10,00					OPEN
0,78	184	0,00		-5,10	1,72	121	0,00		-7,88					OPEN

1,16	226	0,00		-5,20	1,82	224	0,00		-6,20					OPEN
8,98	153	0,00		-3,37	3,23	248	0,00		-2,95					OPEN
10,80	141	0,00		-3,40	1,90	163	0,00		-2,75					OPEN
12,88	150	0,02		-3,38	3,53	155	0,00		-2,70					OPEN
13,82	135	0,00		-3,12	4,62	181	0,00		-2,44					OPEN
10,53	145	0,04		-2,80	6,22	158	0,00		-2,44					OPEN
12,58	144	0,03		-3,05	11,04	157	0,00		-2,10					OPEN
14,08	146	0,35		-3,25	12,52	169	0,12		-2,73					OPEN
12,25	146	0,43		-3,43	16,20	169	0,02		-3,28					OPEN
12,63	139	0,27		-3,37	18,07	176	0,02		-2,62					CLOSED
15,12	143	0,58		-3,36	15,28	173	0,08		-2,45					CLOSED
13,37	139	0,07		-2,48	17,73	175	0,00		-1,50					CLOSED
10,52	145	0,02		-0,78	14,67	192	0,17		-1,23					CLOSED
11,73	156	0,00		-0,43	14,33	195	3,96		-0,70					CLOSED
12,24	153	0,00		-0,76	15,88	196	0,00		-1,26					CLOSED
10,17	143	0,00		-0,58	15,83	191	0,03		-0,90					CLOSED
12,92	150	0,00		-0,98	16,05	190	6,15		-1,28					CLOSED
10,22	148	0,00		-0,46	15,35	210	0,00		-0,43					OPEN
12,95	148	0,03		-0,93	18,28	191	0,08		-1,40					OPEN
12,90	154	0,00		-1,17	16,65	195	0,00		-1,26					OPEN
14,38	154	0,00		-1,18	16,92	184	0,00		-1,32					OPEN
13,47	158	0,03		-1,47	18,12	187	0,00		-1,28					OPEN
12,80	154	0,10		-1,63	17,17	197	0,00		-1,58					OPEN
11,23	151	0,02		-1,42	14,73	189	0,00		-1,25					OPEN
12,13	158	0,00		-1,18	14,62	194	0,00		-1,08					OPEN
10,32	139	0,00		-2,43	2,40	194	0,00		-2,97					OPEN
9,27	138	0,00		-2,30	3,12	208	0,00		-1,58					OPEN
3,77	208	0,00		-2,17	3,78	249	0,00		-1,28					OPEN
5,82	135	0,00		-2,28	2,80	181	0,00		-2,87					OPEN
8,13	134	0,00		-2,40	2,13	45	0,00		-3,42					OPEN
10,15	140	0,03		-2,48	2,44	60	0,02		-3,58					OPEN
9,40	135	0,00		-2,93	3,03	107	0,00		-2,78					OPEN
7,35	149	0,00		-2,60	7,38	182	0,00		-2,54					OPEN
8,85	165	0,00		-2,70	5,68	207	0,00		-2,50					OPEN
10,27	144	0,00		-2,27	6,22	185	0,00		-1,96					OPEN
6,98	145	0,00		-1,98	4,68	185	0,00		-1,58					OPEN
11,88	144	0,20		-2,08	6,33	177	0,02		-1,40					OPEN
12,00	137	0,82		-1,74	2,54	176	0,04		-2,70					OPEN
12,20	129	0,25		-1,43	5,40	44	0,02		-3,12					OPEN
14,65	127	0,40		-1,33	3,20	115	0,00		-2,30					OPEN
14,43	138	0,18		-1,67	5,18	131	0,00		-1,90					OPEN
12,90	137	0,72		-1,87	8,16	151	0,04		-1,36					CLOSED
13,83	145	0,23		-1,92	12,92	159	3,87		-1,45					CLOSED
10,72	144	0,00		-1,78	11,22	181	0,00		-1,40					CLOSED
10,60	149	0,00		-1,55	11,07	172	0,00		-1,17					OPEN
9,83	141	0,00		-1,65	9,07	173	0,00		-1,17					OPEN
7,60	152	0,00		-1,48	6,48	177	0,00		-1,38					OPEN
8,13	151	0,00		-1,98	2,00	190	0,00		-1,12					OPEN
8,37	153	0,00		-2,20	6,17	199	0,00		-2,40					OPEN
11,66	147	0,02		-2,72	6,17	193	0,02		-2,35					OPEN
10,58	141	0,00		-2,57	4,38	222	0,00		-2,37					OPEN
8,62	140	0,00		-2,20	3,67	280	0,00		-2,07					OPEN
6,58	126	0,00		-1,58	1,48	129	0,00		-4,03					OPEN
0,92	110	0,00		-2,40	1,60	111	0,00		-4,88					OPEN
4,32	141	0,00		-1,86	0,85	191	0,00		-5,98					OPEN
7,50	130	0,00		-2,00	1,24	163	0,00		-6,66					OPEN
2,32	178	0,00		-11,60	2,94	43	0,00		-13,72					OPEN
2,53	222	0,00		-11,68	2,98	46	0,00		-13,77					OPEN
3,12	194	0,00		-11,73	2,58	55	0,00		-14,00					OPEN
3,88	161	0,00		-11,68	2,16	65	0,00		-14,10					OPEN
4,45	123	0,00		-12,12	0,27	37	0,00		-14,28					OPEN
2,30	163	0,00		-11,70	1,64	65	0,00		-14,22					OPEN
4,10	27	0,00		-12,32	2,52	38	0,00		-13,06					OPEN
3,52	139	0,02		-11,32	3,02	49	0,00		-12,53					OPEN

6,25	133	0,05		-11,43	3,18	51	0,00		-12,78					OPEN
15,94	154	0,70		-11,20	6,53	32	0,00		-10,97					OPEN
16,22	144	0,27		-11,32	2,78	204	0,00		-10,03					CLOSED
16,78	140	0,62		-11,62	4,50	208	0,00		-10,33					CLOSED
17,77	147	0,27		-12,13	3,33	223	0,00		-10,90					CLOSED
17,50	131	0,07		-12,28	7,40	176	0,00		-11,13					CLOSED
17,33	139	0,10		-12,25	6,12	109	0,00		-10,72					CLOSED
16,34	135	0,00		-12,03	3,98	320	0,00		-10,26					CLOSED
16,68	139	0,07		-12,07	6,90	265	0,00		-10,90					OPEN
14,18	138	0,05		-12,18	5,28	235	0,00		-11,05					OPEN
15,68	140	0,08		-12,30	4,77	272	0,00		-11,47					OPEN
18,55	144	0,20		-12,45	5,82	202	0,00		-11,38					OPEN
					7,40	268	0,00		-11,38					OPEN
					5,75	259	0,00		-11,82					CLOSED
					4,70	281	0,00		-11,90					CLOSED
					4,18	244	0,00		-11,57					CONVOY
					4,50	100	0,00		-11,83					CONVOY
					5,23	70	0,00		-12,37					CONVOY
					3,16	210	0,00		-12,40					CONVOY
					4,83	184	0,00		-12,28					CONVOY
					3,34	242	0,00		-12,50					CONVOY
					3,92	103	0,00		-12,53					CONVOY
					6,62	185	0,00		-12,62					CONVOY
					7,10	241	0,00		-12,58					CONVOY
					16,37	179	0,03		-12,83					CONVOY
					15,66	187	0,00		-13,14					CONVOY
					18,00	181	0,00		-12,78					CONVOY
					8,10	193	0,00		-12,68					CONVOY
					11,33	192	0,00		-12,40					CONVOY
					13,46	182	0,00		-12,52					CONVOY
					3,05	217	0,00		-12,44					OPEN
					6,94	233	0,00		-12,44					OPEN
					5,30	250	0,00		-11,80					OPEN
					0,54	202	0,00		-23,44	1,34	314	0,00	-20,58	OPEN
					1,12	213	0,00		-23,36	1,87	324	0,00	-20,22	OPEN
					0,00	217	0,00		-24,74	0,48	245	0,00	-21,26	OPEN
					0,00	199	0,00		-25,27	0,46	217	0,00	-23,66	OPEN
					0,00	172	0,00		-25,84	1,10	257	0,00	-23,24	OPEN
					0,96	189	0,00		-15,22	1,00	173	0,00	-16,23	OPEN
					1,03	160	0,00		-12,52	0,95	185	0,00	-15,88	OPEN
					1,28	47	0,00		-11,70	2,48	334	0,00	-17,84	OPEN
					5,80	106	0,00		-8,06	3,82	161	0,00	-10,93	OPEN
					14,76	182	0,00		-6,96	5,38	217	0,00	-8,45	CLOSED
					3,13	272	0,00		-6,00	1,78	124	0,00	-9,05	CLOSED
					2,32	205	0,00		-6,42	2,50	204	0,00	-9,40	OPEN
					2,74	164	0,00		-7,80	1,04	150	0,00	-11,34	OPEN
					2,72	82	0,00		-6,96	1,58	257	0,00	-9,80	OPEN
					1,78	70	0,00		-6,20	0,92	311	0,00	-8,90	OPEN
					0,90	226	0,00		-5,38	1,42	331	0,00	-8,68	OPEN
					1,30	259	0,00		-8,05	1,47	182	0,00	-10,12	OPEN
					1,97	108	0,00		-7,75	2,88	300	0,00	-8,38	OPEN
					3,50	251	0,00		-5,14	2,92	232	0,00	-8,38	OPEN
					8,64	241	0,02		-6,72	13,26	270	0,00	-8,62	OPEN
					7,90	254	0,00		-6,58	16,92	280	0,82	-8,90	OPEN
					7,54	265	0,04		-7,04	19,64	293	0,28	-10,20	CLOSED
					7,30	256	0,00		-7,28	21,04	295	0,26	-10,58	CLOSED
					7,28	232	0,00		-7,58	14,58	290	0,00	-10,24	CLOSED
					5,86	255	0,00		-6,82	14,52	292	0,02	-10,18	CLOSED
					5,50	239	0,00		-6,40	16,44	286	0,02	-9,92	CLOSED
					7,40	243	0,00		-6,48	17,18	288	0,00	-9,96	CLOSED
					8,84	227	0,00		-6,50	10,34	284	0,00	-8,16	CLOSED
					5,52	261	0,00		-9,22	8,62	268	0,00	-10,12	OPEN
					4,57	255	0,00		-9,13	9,36	276	0,00	-9,64	OPEN
					3,38	258	0,00		-9,48	6,86	255	0,00	-10,48	OPEN