Potential benefits of Routeinfo.no

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Foreword

On behalf of the Norwegian Coastal Administration, Menon Economics and DNV have shed light on the possible benefits of Routeinfo.no, which supplies quality assured sailing routes between and to ports on the Norwegian coast. Specifically we have:

1. Rough estimates of the potential benefit of routeinfo.no with regards to maritime safety.
2. Qualitative assessments of other potential non-priced benefits, eg reduced use of time in route planning.

Peter Aalen has been the project manager, Sander Rivø Aslesen and Peter Hoffman (DNV) has contributed to the project as participants, while Magnus Utne Gulbrandsen was responsible for quality assurance.

Menon Economics is an employee-owned consultancy operating at the interface of economics, politics and the marketplace. Menon Economics performs economic analyses and provides advice to companies, organizations and authorities. We combine economic and commercial expertise in fields such as industrial organization, strategy, finance, organizational design and cost/benefit analyses.

We wish to thank the Norwegian Coastal Administration for assigning us this interesting project.

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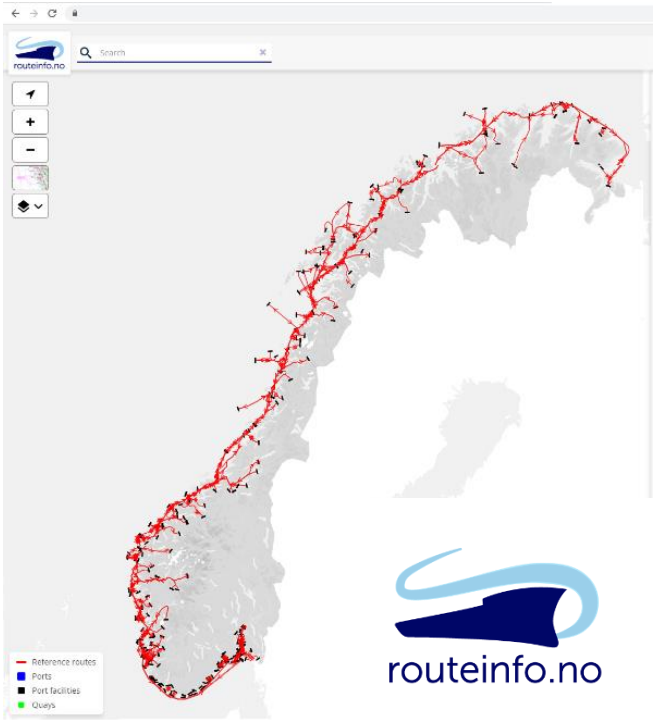
September 2022

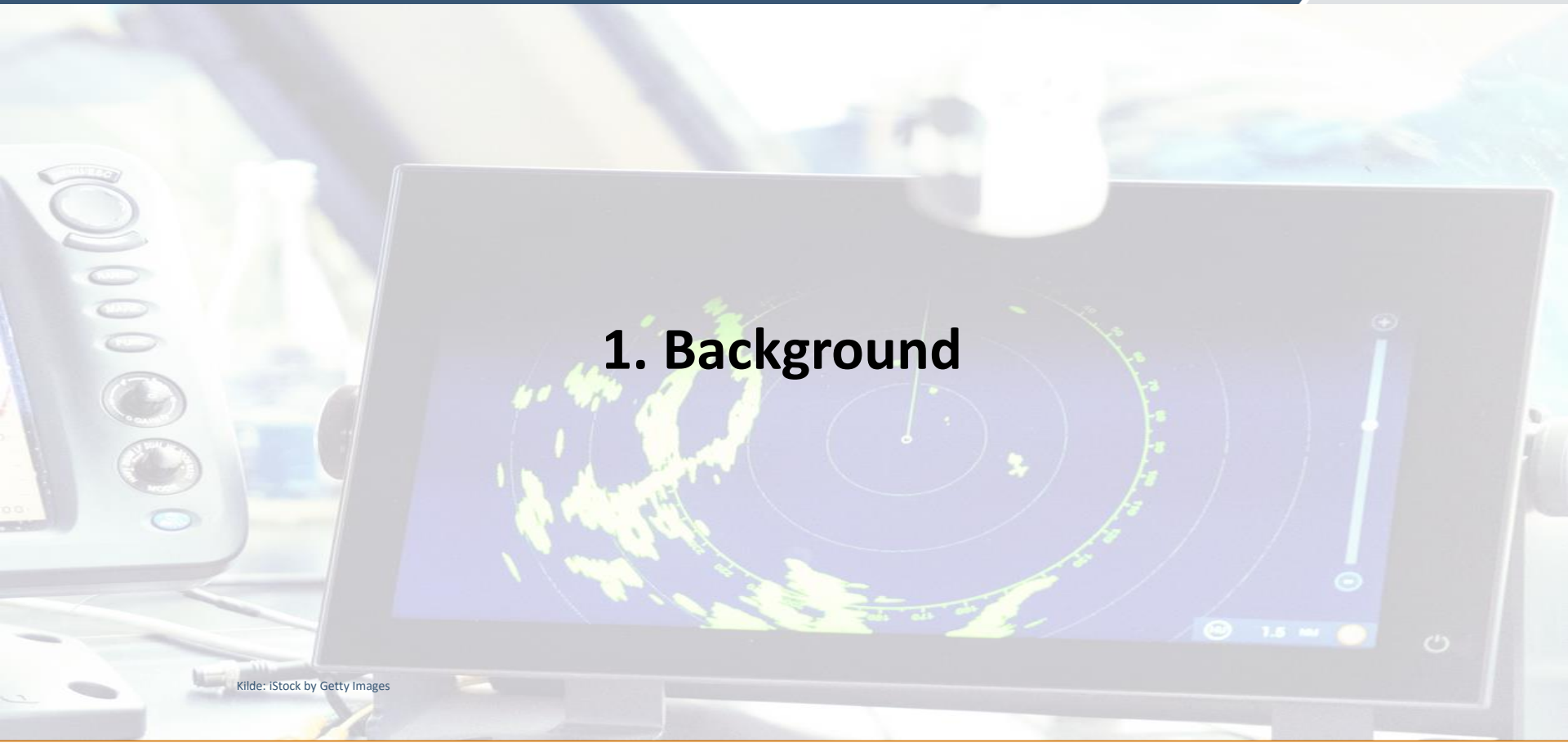
Peter Aalen
Project Manager

INNHOLDSFORTEGNELSE



routeinfo.no

1. Background



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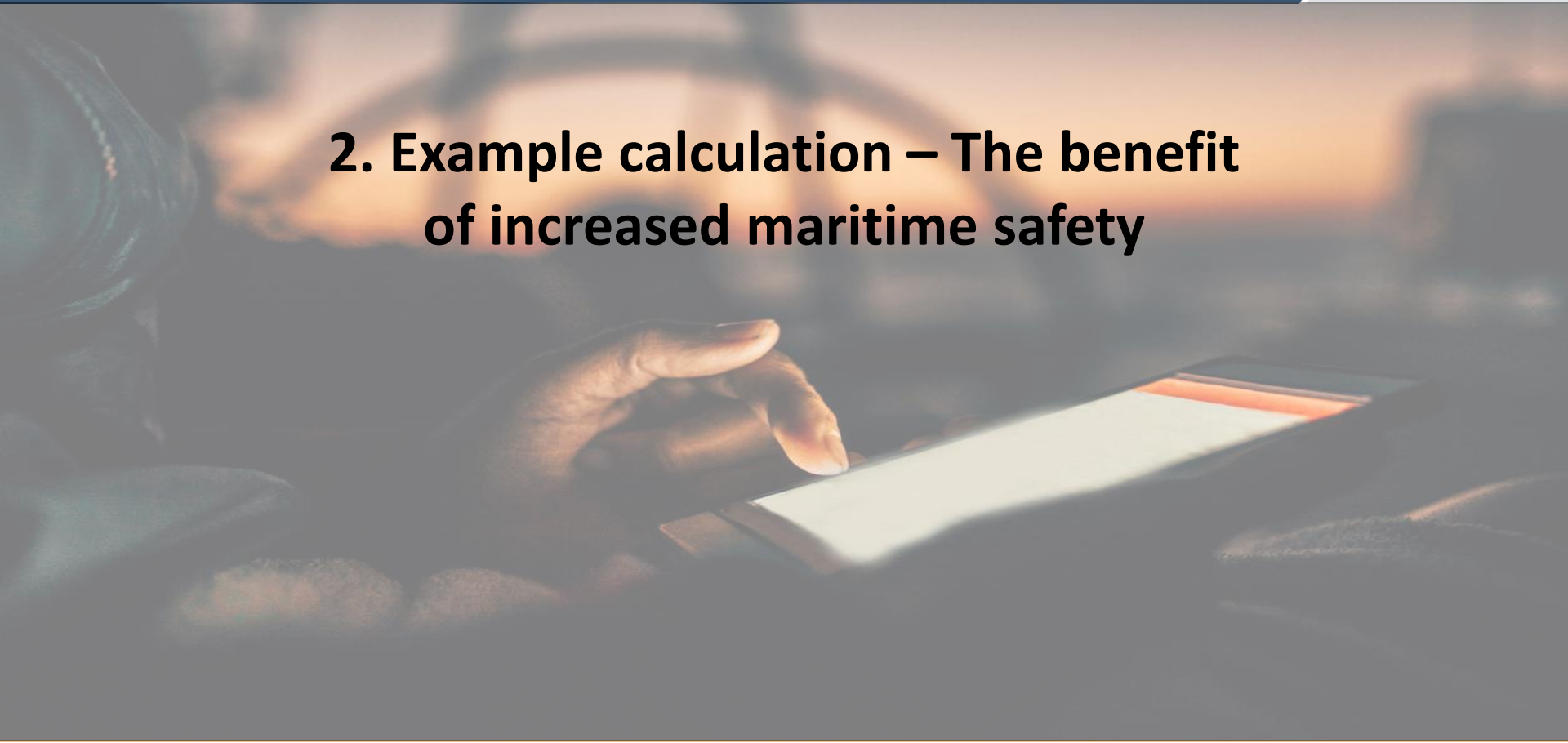
The Norwegian coastal administration has developed quality assured routes covering the entire Norwegian coastline. The digital routes, as well as other relevant route information, are easily accessible through routeinfo.no. The service was launched in 2018, but the amount of routes covered has since been steadily expanded to cover the entire coastline, as well as other improvements. Additionally, the routes are readily available for use as routeinfo.no's API makes it easy to integrate with existing commercial navigation software. It is integrated in Njord Pilot/Orca Pilot which is in use by the 300 ship pilots employed by the Norwegian coastal administration. NAVTOR has integrated the quality assured routes in its route planning software Navstation, which is in use by thousands of ships world wide. The routes are also readily available to several thousand navigators through the navigation service PRIMAR.

Routeinfo.no's routes include key information on, among other things, regulations, limitations and VHF-channels related to the route. The Norwegian coastal administration is working on adding further relevant information, such as bathymetry quality along routes, in a standardized format through routeinfo.no. This would add to the benefits of using their quality assured routes.



2. Example calculation – The benefit of increased maritime safety

MAIN FINDINGS FROM THE FRAM-ANALYSIS

Widespread use of the quality assured routes provided through routeinfo.no has the potential to improve maritime safety through a number of channels. The most important channel is removing one source of human error, namely manually planned voyages. Easy access to such routes will also lower the probability that old, lower quality or outdated routes are kept in use after they have been made and stored. That the routes separate traffic by direction, rather than placing routes in the middle of shipping lanes, could additionally reduce the probability of collisions.

A large number of factors contribute to accidents, including weather conditions, human error and ship malfunctions. As such, the route in itself is rarely the sole reason for any accident, but rather a contributing factor in some accidents. To be able to provide rough estimates of the benefit of increased maritime safety that routeinfo.no could provide, one needs to estimate the marginal accident risk reduction associated with using the quality assured routes, all else equal.

DNV and the Norwegian Coastal Administration estimated said risk reduction in co-operation, based on the observed numbers of groundings and collisions involving ships of length above 70m, that could possibly have been prevented using routeinfo.no in the period 2015 through may 2022. No recent collisions were found to be preventable through routeinfo.no. Though the sample size is far smaller and thus the uncertainty larger for collisions, this result points clearly towards a higher grounding risk reduction, than that of collisions. For illustrative purposes and based on input from maritime safety experts in DNV, we have assumed a risk reduction of 1 percent for collisions. The figure should be interpreted as a highly uncertain, but realistic upper bound. The grounding risk reduction is less uncertain and can be interpreted as an expected value.

Potential accident risk reduction due to routeinfo.no

*Historically observed **groundings** potentially avoided:* **1 percent**

*Historically observed **collisions** potentially avoided:* ***0*** **percent**

*Assumed upper bound of **collisions** potentially avoided:* **1 percent**

Historical estimates based on accidents involving ships with length>70m in Norwegian waters, 2015-2022

MAIN FINDINGS FROM THE FRAM-ANALYSIS

To get and provide rough estimates of the benefit of the potential risk reduction associated with introducing quality assured sailing routes for the Norwegian coast, through routeinfo.no, we have conducted two analyses using FRAM. FRAM is the Norwegian coastal administration's model to calculate costs and benefits at sea. First, we perform an analysis where we reduce the probability of grounding by 1 percent, thereafter we perform another analysis where we reduce the probability for collision by 1 percent. The results are thereafter analyzed in a cost-benefit framework and a net present value over ten years is calculated.

Routeinfo.no is primarily used by ships above 70 meters. Additionally, the accident data we have used to evaluate the risk reductions only cover accidents concerning such ships. The analysis restricts itself to benefits for ship of length above 70 meters.

The results are highly uncertain and do not take other costs or benefits into consideration. They do, however, illustrate the possible benefits the quality assures routes provided by the Norwegian Coastal Administration through Routeinfo.no, could deliver through improved maritime safety.

Given our assumptions, our rough estimates of the net present value of the benefit of reduced risk of grounding over the forthcoming ten year period amounts to 37 MNOK. The equivalent figure is 8 MNOK for collisions, but this estimate is more uncertain and must be interpreted as an upper bound. In total the potential benefit adds up to 45 MNOK.

The benefit of improved maritime safety
(net present value over 10 years)

Grounding:
NOK 37 million

Collision:
Up to NOK 8 million

Joint potential benefit:
NOK 45 million

It is important to note that the benefits above does not take incurred costs of implementation of routeinfo.no. Thus, the report simply shows the potential benefits of routeinfo.no with regards to maritime safety.

ASSUMPTIONS AND DATA IN THE EXAMPLE CALCULATION

To perform the analysis, and the following example calculations we have had to make a series of an assumptions. In this slide we present FRAM and lay out what assumptions it rests on, and which adjustments we have done for this specific analysis. We also cover the assumptions made about the risk reductions in grounding and collisions.

FRAM is the Norwegian Coastal Administrations own model for performing cost-benefit analyses. FRAM rests on a series of assumptions. Most of these assumptions are based on observed accidents within each ship type and ship size. These standard values are usually used to calculate what the benefit of a given risk reduction per port call is. In this case we are less interested in the accident probability associated with port calls, but rather what is the benefit of a given reduction in each type of accident, which necessitated tweaking FRAM.

The benefit of avoiding an accident depends on the ship type and size of the ship in question, while quality assured routes potentially reduces the overall risk of accidents. We have conducted a FRAM-analysis for each type of accident (collision and grounding) to calculate the benefit of ***one*** less accident of each type, where the benefit of avoiding the accident is the weighted average of ship types and sizes. The weights were calculated by DNV and based on modeled accident risk for each size and ship type in Norwegian waters, informed by historical accident rates and ship calls.

Thereafter, we have used average observed numbers for accidents involving ships with length above 70 meters for the period 2015-2022, as supplied by the Norwegian Coastal Administration. We then use calculated benefit of one less accident and a yearly risk reduction of 1 percent for both groundings and collisions, respectively. Multiplied together, we get a rough estimate of the potential yearly benefit with regards to maritime safety of routeinfo.no.

The risk reduction figures are based on the Coastal administration categorization of each observed accident that has occurred since 2015. Firstly, a category where routeinfo.no to a large extent would have helped avoid the accident (20-25%), one where routeinfo.no would have helped to some extent (5%-10%), and one category where routeinfo.no would not have reduced the accident risk at all. According to the classification, no recent collisions could have been avoided by using quality assured routes. As the sample size of collisions is far smaller than that of groundings, one cannot rule out that routeinfo.no could bring a small reduction in collision risk. Based on our knowledge of maritime safety, and as an upper bound, we have set the collision risk reduction associated with quality assured routes to 1 percent, to illustrate the benefit potential of reduced collision risk.

Routeinfo.no is mainly used by ships with length greater than 70 meters, and risk reduction estimates are based on such ships. For this reason, we have restricted the analysis to ships of length greater that 70 meters. This necessitated a reweighting FRAMs accident probability matrix. This is described in greater detail in appendix A.

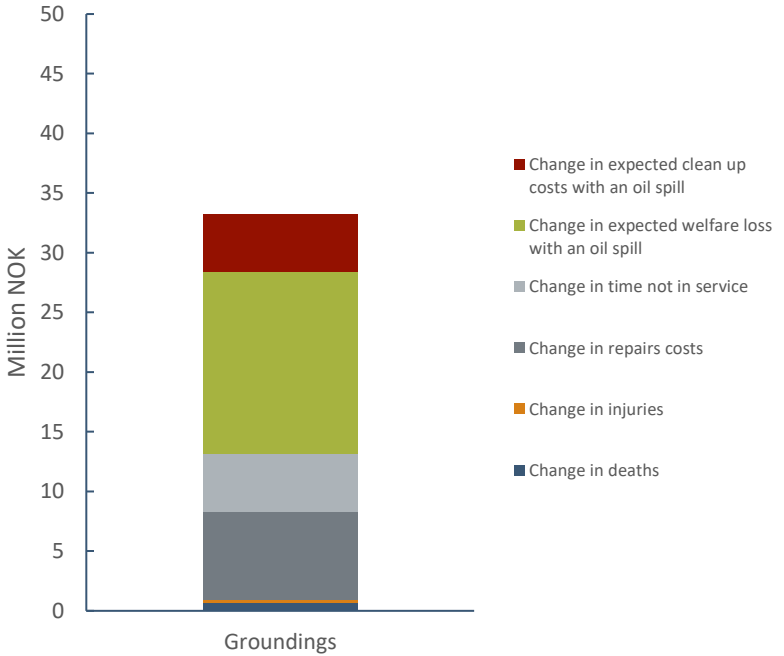
BENEFITS OF REDUCED NUMBER OF GROUNDINGS

The first FRAM simulations we run is to calculate the benefits related to one avoided grounding. I.e., we find the marginal value of one typical grounding accident, where we take into consideration that risks and consequences of accidents depend on the type of ship and its length. The figure to the right shows the results from the model by benefit category.

As seen, the total value of avoiding one typical grounding of a ship above 70 meters is about NOK 33 million. The largest cost categories are related to the expected welfare loss due to an oil spill and repair costs. This is fairly natural, as the marginal willingness to pay to avoid an oil spill is relatively high. Also, ships larger than 70 meters have relatively higher costs of repairs. These two categories make up roughly 70 percent of the total benefits related to one avoided grounding accident.

Of the remaining ~10 MNOK, about 8 million of these stem from expected clean up costs and loss of time in service. Thus, these four categories make up about 97 percent of the benefit related to one fewer grounding accident.

Figure: The benefit of one less grounding from FRAM



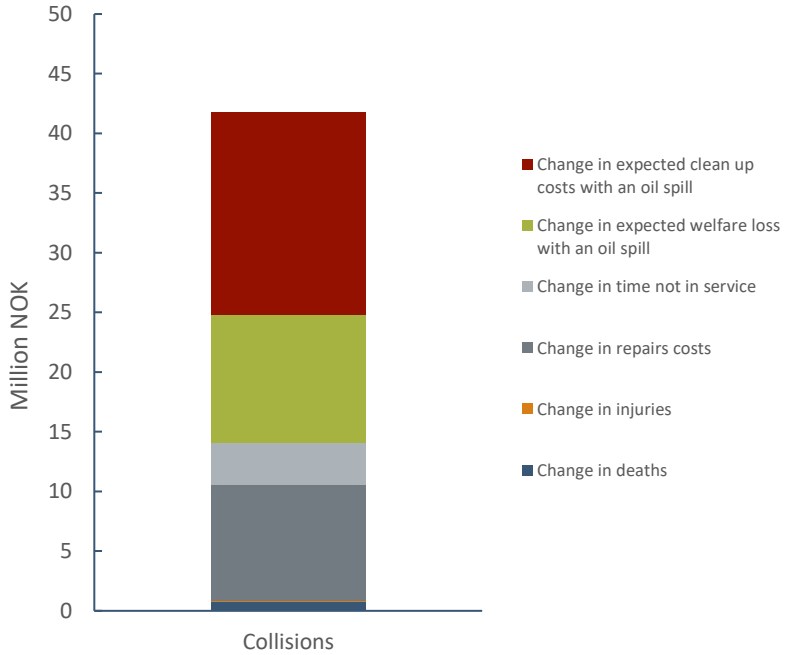
BENEFITS OF REDUCED NUMBER OF COLLISIONS

The second FRAM simulation we ran is to calculate the benefit related to one single reduction in collisions. I.e., we find the marginal value of one typical grounding accident, where we take into consideration that risks and consequences of accidents depend on the type of ship and its length, and if it is the striking ship or if it is being struck by another ship. The figure to the right shows the results from the simulations broken down into different benefit categories.

As seen, the value of one avoided collision is around NOK 42 million. The largest cost categories are related to the change in expected clean up costs due to an oil spill, expected welfare loss due to an oil spill and repair costs. These three categories make up roughly 90 percent of the total benefits of one avoided collision. Of the remaining benefits, the lost time in service is the largest, making up about 75 percent of the benefit not accounted for by the three largest categories.

This implies that a typical collision involves higher costs than a typical grounding. This is because one collision must involve two ships, increasing the costs related to ship damages. Additionally, in head-on collisions, the momentum in the accident is larger. It is more costly to crash into another ship, than to hit ground. What is interesting is how the benefits are a bit differently distributed, as the benefits of avoiding a collision to a larger extent relate to the expected clean up costs due to an oil spill. Again, this stems from the fact that two damaged ships spill more oil than one single ship alone. It is also important to notice that the four largest categories are the same for both groundings and collisions.

Figure: The benefit of one less collision from FRAM



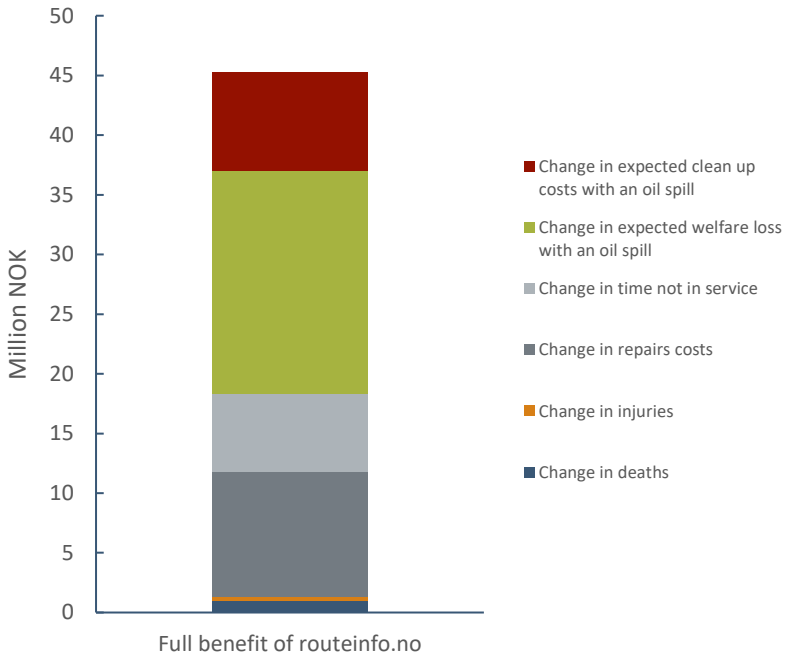
In our rough estimates of the potential total benefits of routeinfo.no we look at the 10-year net present value of a 1 percent decrease in the frequency of groundings, and a 1 percent decrease in the frequency of collisions. Reducing the frequency of groundings by 1 percent translates into roughly 0,13 fewer accidents per year. Reducing the frequency of collisions by 1 percent translates to roughly 0,02 fewer collisions accidents per year. We discount the yearly benefit over a 10-year period in line with the Norwegian ministry of finance guidelines for cost-benefit analyses (circular R-109). The figure to the right shows how the 10-year discounted benefit distributed across the different benefit categories.

As we can see from the figure, the total benefits from routeinfo.no are roughly NOK 45 million. Of this, about NOK 37 million are due to the avoidance of groundings, while about NOK 8 million are due to the reduction of collisions. Avoidance of groundings contribute the bulk of the benefits, as both the observed frequency of groundings and the estimated risk reduction are much higher than that of collisions.

The total benefits are distributed similarly to the distribution of benefits for groundings, as should be expected when most of the benefits stem from the avoidance of this accident type.

We emphasize that the assumed collision risk reduction is included for illustrative purposes and based on input from maritime safety experts in DNV rather than observed accidents potentially avoided. Thus, estimates for collisions are more uncertain than those for groundings, and a 1 percent risk reduction is likely to be in the upper deciles of realistic collision risk reductions. As shown by our analysis, reducing grounding risk is in any case of far greater importance to maritime safety than that of collisions, due to the higher frequency of groundings.

Figure: 10-year discounted benefit of a 1 percent reduction in groundings and a 1 percent reduction in collisions, distributed on different benefit categories.



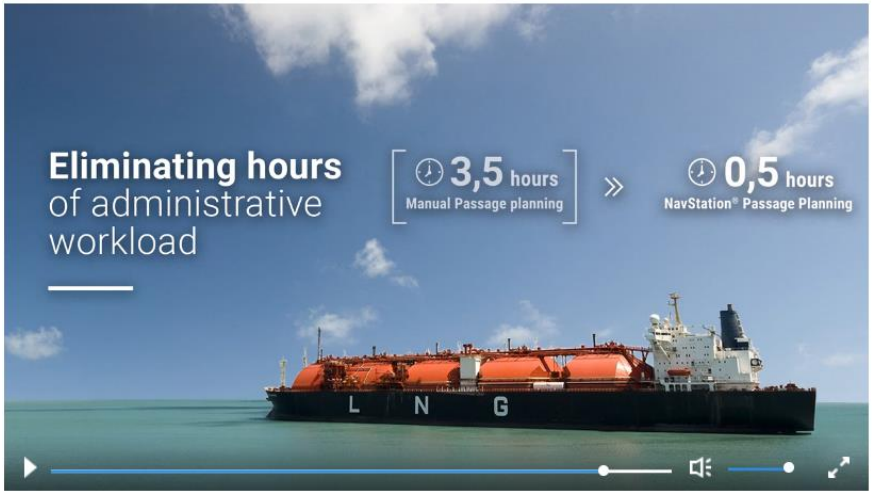
3. Time savings and other effects

OTHER EFFECTS: TIME SAVINGS IN ROUTE PLANNING

The quality assured routes of Routeinfo.no could save time in planning voyages by reducing the need for manual voyage planning. Time saved in planning routes improves efficiency in shipping and as such, is a benefit. The quality assured routes provided through routeinfo.no should contribute to significant benefits in that regard, as navigators can trust that the routes are safe and efficient.

That the routes are readily available for use through routeinfo.no's API makes them easy to integrate with existing commercial navigation software. They are integrated in Njord Pilot/Orca Pilotm which is in use by the 300 ship pilots employed by the Norwegian coastal administration. Additionally, NAVTOR has integrated the quality assured routes in its route planning software Navstation, which is in use by thousands of ships worldwide. The routes are also readily available to several thousand navigators through the navigation software PRIMAR.

This ease of access to the routes increases the time saved per route planned, as well as increasing the adoption rate of the routes, which further increases the potential time savings. NAVTOR claims that the time spent on voyage planning can be reduced from 3,5 to 0,5 hours, using quality assured routes through its software, compared to manual planning. This estimate is likely to represent an upper bound on potential time savings per route planned, for several reasons. Firstly, a part of the time saved is due to the NAVTOR software, rather than solely Routeinfo.no. Secondly, in a high proportion of cases, the alternative to the routes supplied by Routeinfo.no is not manually planning a route from scratch. In practice, navigators often re-use previously planned routes, potentially of poor quality, stored in the ship navigation software, rather than manually planning the route before each voyage. This greatly reduces the potential time savings routeinfo.no could generate. Routeinfo.no's routes will in most cases be of higher quality, but using a ready-made higher quality route rather than re-using a readily available one of poorer quality does not translate into significant time savings in voyage planning.



OTHER EFFECTS: TIME SAVINGS IN INFORMATION GATHERING AND THE EFFICIENCY OF SAILED ROUTES

Routeinfo.no's routes include key information on, among other things, regulations, limitations and VHF-channels related to the route. This is information needed in voyage planning, which otherwise would have to be gathered manually through different sources. Navigators might in some cases not gather the entirety of this information when using previously planned routes. In such cases, having the information easily accessible could improve maritime safety, while the fact that it is available through routeinfo.no could add further time savings in other cases. Having such information documented in the voyage plan also reduces the chance of some information not being handed down when changing crews and navigators.

The Norwegian Coastal Administration is working on adding further relevant information, such as bathymetry quality along routes, as a new element in the route information. This would add to the benefits of using their quality assured routes. Furthermore, the reference routes provide a good indication of where good quality bathymetry is needed. The Norwegian Hydrographical Service (Kartverket) have since 2019 used the reference routes to better prioritize new depth surveys to increase safety at sea. This has for example improved the utility of depth surveys conducted on Svalbard over the last three years.

Good management of the route information and routes on new digital standards, open up the information to be used for other purposes than route planning. For example, routes can be utilized as part of maritime reporting. They can be used for sharing information between different maritime stakeholders. The pilot and the navigator can now easily exchange relevant regulations for a sailing route. This could lead to further efficiency and/or safety gains.

Lastly, quality assured reference routes could on average be more efficient and shorter than the routes navigators otherwise would plan. The quality assured routes include an optimized number of waypoints and an efficient route through shipping lanes. Due to time constraints while planning routes or other factors, navigators planning routes manually could on the other hand be expected to optimize the route to a lesser degree. Thus, widespread use of quality assured routes, could possibly lead to time and fuel savings.

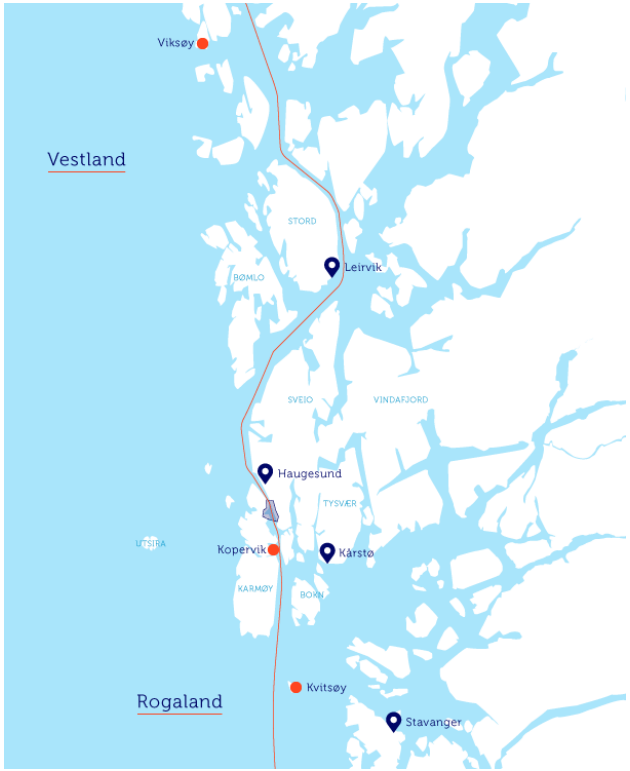
OTHER EFFECTS: TIME SAVINGS IN ROUTE PLANNING AND INFORMATION GATHERING

We conclude that the quality assured routes could significantly reduce time spent on voyage planning. Additionally, they likely provide further benefits through more efficient information gathering, and possibly through shorter routes, as well as efficiency gains through improved prioritization of areas in need of improved depth data and other spill-over effects of improved information management and availability. We cannot, however, quantify the monetary value of these benefits.

In this project, we originally set out to measure time savings per voyage planned with routeinfo.no compared to manual planning, through a series of tests with 3rd year nautical students. Due to COVID-restrictions at the relevant colleges, we were only able to conduct one minor test. Thus, we had to abandon the plan. Additionally, the one test conducted, revealed that creating a test environment that could give results that would reasonably represent the average real life voyage planning situation, proved difficult.

Furthermore, the scope of the project did not allow for the complex task of estimating the number of voyages that would accrue time savings. Estimating this key figure is complicated significantly due to the fact that it is unknown to which degree routeinfo.no's routes substitute manual planning, as opposed to pre-existing lower quality routes. While the maritime safety benefit could be significant in the latter case, time savings will at best be marginal per voyage.

Further research needs to be conducted to reasonably quantify the benefits of time savings and other efficiency gains in monetary terms.



Appendix

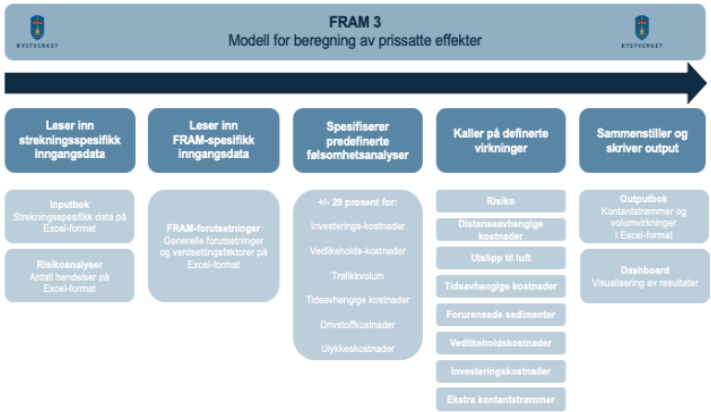
Appendix A: Assumptions and Fram calculations

As mentioned in the report, FRAM is the Norwegian Coastal Administrations own model for performing cost-benefit analyses. FRAM's main purpose is to illustrate and calculate the total effect of certain measures related to seaways. So, one example could be that FRAM would calculate the cost and benefit of ground deepening one sea way into a dock. Technically, FRAM does this by calculating the expected benefit from the reduction in accidents to sea, while also controlling for the cost of implementing the measure. In its calculations, FRAM will include all costs related to the measure. Such as time depending costs, local emissions, increased costs of fuel etc. Keeping the benefit fixed to the number of accidents reduced.

In our case, we were interested in the benefit of a general risk reduction along the entire Norwegian coast, rather than a localized effect. To calculate this we have run a simulation of FRAM that includes one typical grounding and another one that includes one typical collision. This gives us the unity valuation of one accident, and implicitly the total cost of one accident, whether it is groundings or collisions.

Using the expected number of groundings and collisions respectively, in combination with the expected risk reduction, supplies us with the expected number of each type of accident avoided yearly over the period 2023-2032. We have assumed that the number of accidents grows by 1,4 percent yearly, in line sea traffic prognosis. The expected reduction in each type of accident is then multiplied with the valuation of a single accident of that type.

Illustration of FRAM 3 calculation methods.



Appendix A: FRAM input and frequency matrix

The valuation of the typical grounding and collision, respectively, takes into account that the cost of accidents depend on ship type and size. The weights are based on the expected accident probability of each type and length combinations, as estimated by DNV GL. This is used to implicitly calculate the benefits because what type of ships that collide or grounds are an important assumption in the calculation.

Routeinfo.no is primarily used by ships above 70 meters. Additionally, the accident data we have used to evaluate the risk reductions only covers accidents concerning such ships. Thus, we have re-weighted the probability matrixes to only include accident risk for ships of length above 70 meters. The relative probability for each ship type- and size is kept intact, and the probabilities sums up to exactly 1. The re-weighted probability matrixes employed are shown to the right.

Probability of groundings

Skipstype Kystverket	0-30	30-70	70-100	100-150	150-200	200-250	250-300	300-	Sum
Oljetankskip	0E+00	6E-04	5E-02	2E-02	5E-03	1E-03	9E-04	6E-05	**7E-02**
Kjemikalie-/Produktskip	0E+00	0E+00	1E-02	5E-03	1E-03	4E-04	2E-04	2E-05	**2E-02**
Gasstankskip	0E+00	0E+00	4E-02	2E-02	5E-03	1E-03	9E-04	6E-05	**7E-02**
Bulkskip	0E+00	0E+00	2E-01	9E-02	2E-02	7E-03	4E-03	3E-04	**3E-01**
Stykkgods-/Roro-skip	0E+00	0E+00	1E-02	4E-03	1E-03	4E-04	2E-04	2E-05	**2E-02**
Containerskip	0E+00	0E+00	8E-02	3E-02	8E-03	2E-03	1E-03	1E-04	**1E-01**
Passasjerbåt	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	**0E+00**
Passasjerskip/Roro	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	**0E+00**
Cruiseskip	0E+00	0E+00	9E-02	4E-02	1E-02	3E-03	2E-03	1E-04	**1E-01**
Offshore supplyskip	0E+00	0E+00	5E-02	2E-02	6E-03	2E-03	1E-03	7E-05	**8E-02**
Andre offshorefartøy	0E+00	0E+00	2E-02	9E-03	3E-03	8E-04	5E-04	3E-05	**4E-02**
Brønnbåt	0E+00	0E+00	1E-04	5E-05	1E-05	4E-06	3E-06	2E-07	**2E-04**
Slepefartøy	0E+00	0E+00	2E-02	9E-03	3E-03	7E-04	4E-04	3E-05	**4E-02**
Andre servicefartøy	0E+00	0E+00	4E-02	1E-02	4E-03	1E-03	7E-04	5E-05	**6E-02**
Fiskefartøy	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	**0E+00**
Annet	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	**0E+00**
Sum	**0E+00**	**6E-04**	**6E-01**	**2E-01**	**7E-02**	**2E-02**	**1E-02**	**9E-04**	**1E+00**

Probability of collisions

Skipstype Kystverket	0-30	30-70	70-100	100-150	150-200	200-250	250-300	300-	Sum
Oljetankskip	0E+00	0E+00	3E-02	1E-02	4E-03	3E-03	2E-03	1E-04	**5E-02**
Kjemikalie-/Produktskip	0E+00	0E+00	5E-02	2E-02	7E-03	4E-03	3E-03	2E-04	**8E-02**
Gasstankskip	0E+00	0E+00	1E-02	5E-03	2E-03	1E-03	7E-04	5E-05	**2E-02**
Bulkskip	0E+00	0E+00	5E-02	2E-02	7E-03	4E-03	3E-03	2E-04	**8E-02**
Stykkgods-/Roro-skip	0E+00	0E+00	2E-01	9E-02	3E-02	2E-02	1E-02	9E-04	**4E-01**
Containerskip	0E+00	0E+00	1E-02	5E-03	2E-03	1E-03	7E-04	5E-05	**2E-02**
Passasjerbåt	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	**0E+00**
Passasjerskip/Roro	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	**0E+00**
Cruiseskip	0E+00	0E+00	1E-02	4E-03	2E-03	1E-03	6E-04	4E-05	**2E-02**
Offshore supplyskip	0E+00	0E+00	9E-02	4E-02	1E-02	8E-03	5E-03	4E-04	**2E-01**
Andre offshorefartøy	0E+00	0E+00	5E-02	2E-02	8E-03	5E-03	3E-03	2E-04	**9E-02**
Brønnbåt	0E+00	0E+00	2E-02	9E-03	4E-03	2E-03	1E-03	1E-04	**4E-02**
Slepefartøy	0E+00	0E+00	1E-04	5E-05	2E-05	1E-05	8E-06	5E-07	**2E-04**
Andre servicefartøy	0E+00	0E+00	2E-02	9E-03	3E-03	2E-03	1E-03	9E-05	**4E-02**
Fiskefartøy	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	**0E+00**
Annet	0E+00	0E+00	6E-03	2E-03	9E-04	5E-04	3E-04	2E-05	**1E-02**
Sum	**0E+00**	**0E+00**	**6E-01**	**2E-01**	**9E-02**	**5E-02**	**3E-02**	**2E-03**	**1E+00**

MENON ECONOMICS

POTENTIAL BENEFITS OF ROUTEINFO.NO

AUGUST 2022