Analysis Of The Main Challenges With The Current Risk Model For Collisions Between Ships and Offshore Installations On The Norwegian Continental Shelf.

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Abstract:
The last decade has seen the implementation of numerous navigation aids, safety barriers and various tools to ensure the safe navigation and operation of ships. Still, a significant amount of ship collisions and groundings occur every year. The COLLIDE risk model became the industry standard about 20 years ago for calculating the risk of ship collisions against offshore installations on the Norwegian Continental Shelf (NCS). The risk model is currently being revised, in order to take account for the new technology that has entered into the arena. Technological advances have significantly changed the way seafarers operate and navigate. During the last decade, navigators have had to learn new skills and adapt to a new working environment, and this affects safety in many ways. Human and organizational factors (HOFs) have a large impact on complex systems, such as ship operations, and should be given equal and appropriate attention when risk is being investigated and assessed. Too many risk models are applying research on HOFs of questionable quality, using parameter values that may no longer be valid. This paper presents challenges with the current industry standard COLLIDE-methodology and highlights areas where improvements and alternatives to the current model are needed. Relevant issues regarding future research in this area are also discussed.

Keywords: AIS, Ship Collision, Risk Model, Allision, Collision Risk, COLLIDE

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1. INTRODUCTION

Offshore oil and gas installations depend on support vessels for a wide range of tasks, from delivering supplies to performing installation work and underwater inspections. In addition to field related vessels visiting installations, regular merchant shipping is crisscrossing the oceans all around the installations, and few other scenarios have the level of accident potential as a collision between a ship and an installation. The risk posed by ships has been known for a long time, and the frequencies of incidents have been significant compared to the order of magnitude for most other incidents covered by normal quantitative risk assessments (QRAs). Increasingly complex field developments, support vessel design and general technological development of the tools used onboard vessels of all types may be a reason why ship collision still is one of the major risk contributors [1].

The Norwegian Petroleum Safety Authority (PSA) states in the Facilities regulations [2] that: *"Accidental loads/actions ... with an annual probability greater than or equal to 1* $\times 10^{-4}$*, shall not result in loss of a main safety function."* The definition of main safety function (MSF) consists of several items, of which the following is relevant in this context: *"...maintaining the capacity of load-bearing structures until the facility has been evacuated..."*. The PSA operates with a list of "defined hazard and accident conditions" (DFUs), where the risk of ship collision is one such DFU [3]. Most offshore oil and gas installations will be able to withstand minor impacts with vessels engaged in offshore-related activity while they are maneuvering close to the facility at low speed. They are, however, not designed to withstand a collision with a large vessel at high speed, and such an event has the potential to cause structural damage that in worst case could result in a complete collapse of the structure. Hence, the offshore oil and gas industry operating on the Norwegian Continental Shelf is obliged to perform risk assessments showing that the risk posed by a potential ship collision with

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energy above the impairment threshold for the installation in question is below the required acceptance level of 1 event per 10.000 installation-years.

The COLLIDE risk model [5] has been used to determine the risk of ship collisions towards offshore installations for about two decades, and it is the industry standard for determining the quantitative probability of collisions. The model was developed in a joint project including several industry partners and NTNU, building upon an earlier Norwegian research program, RABL (Risk Assessment of Buoyancy Loss) [4]. One of the goals for the RABL project was to develop a methodology for risk analysis for offshore structures with regards to collision risk, and when it later became apparent that collision risk was one of the major risk contributors, the COLLIDE project was initiated [5].

The COLLIDE risk model is based on an initial mapping and processing of ship movement data, such as Automatic Identification System (AIS) data. This constitutes the basis for probability calculations, and is essentially a grouping of vessel tracks into a traffic pattern of shipping lanes with attributes, such as statistical distribution, standard deviation and traffic volume. The COLLIDE risk model uses this information along with a wide set of fixed and dynamic variables to calculate collision frequencies. Since the model was developed about two decades ago, new systems and barriers have been implemented for ships and petroleum companies operating offshore installations. Hence, there is a need for a new revision to incorporate these new aspects and elaborate certain components of the model. Components, such as human error and operational procedures, are currently oversimplified in order to enable calculation of variables that are hard to quantify. New research is currently underway to mitigate this situation, so that a more holistic approach may be incorporated in the new risk model.

Most research in the realm of anti-ship-collision seems to be focused on technical aids and the development of new tools and technologies, adding to an already complex working environment for navigation officers and crewmembers. It is reasonable to ask why there is not more research performed on the actual operational situation onboard offshore vessels and merchant shipping vessels.

A significant amount of research has investigated the structural response and general strength of ships and installations in case of ship collisions [6, 7]. Goerlandt and Kujala [8] focus on ship-ship collision scenarios, but very little exists on the probabilities of a ship collision with a stationary offshore installation. The RNNP[†] project [9] by the PSA does extensive data collection, and even though the DFU for a ship on collision course consistently is one of the most significant risk factors with regards to major accident risk, the issue is seldom discussed in detail. According to Okstad et al. [10] one of the accident types that contributed most to the major accident risk is ships on collision course, and this has remained stable for several years. Many reasons are given why researchers tend to not go in greater detail of this topic, and to quote Vinnem [11]: *"The data shows that there are significant annual number of precursors for DFU nos. 1, 3 and 5. DFU5 represents external merchant vessels on collision course, and the occurrence of such events is thus not representative for the safety management on the installation."*

The PSA has instructed the industry to focus more on field related offshore vessels, and the risk they pose to the installation, contrary to unrelated merchant shipping transiting through the area [11]. Statistics collected by the PSA verify this concern [11], as there has not been any incident of merchant ships on collision course actually leading to a high-speed collision with an offshore installation on the Norwegian Continental Shelf, and only one incident in neighboring areas. (A small cargo vessel hit a Norwegian operated platform on the German Continental Shelf in 1995.) [12] Several incidents, however, involving a range of vessels, from well intervention vessels [13] to offshore supply vessels [14], have shown that field related vessels may in fact pose a more significant threat to installations. The PSA has registered 26 collisions between facilities and field related (visiting) vessels on the Norwegian shelf during the last 10 years, of which six had major accident potential [15]. Hence, it is necessary to have a good risk model capable of quantifying the probability of a ship collision with a stationary installation. COLLIDE is currently being revised, in order to update core assumptions and

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[†] RisikoNivå i Norsk Petroleumsvirksomhet (Trends in risk level in the Norwegian petroleum industry)

methodology to better model the current situation of ship navigation in the vicinity of offshore installations, and the risk of collision from merchant shipping passing through the area.

The objective of this paper is to present challenges with the current industry standard COLLIDE risk model and highlight areas where improvements and alternatives to the current model is needed. Relevant issues regarding the need for further research in this area are also discussed. This paper only addresses issues with the current COLLIDE risk model methodology and does not discuss the collection and preparation of input data. This paper is structured as follows: Section 2 presents the COLLIDE risk model and the various components it is made up of while Section 3 highlights issues with the model and discusses alternative solutions. Lastly, conclusions are stated.

2. THE COLLIDE RISK MODEL

Quantitative risk models of ship collisions invariably use some form of traffic data as the basis for further calculations. The input to the COLLIDE model is traffic and vessel data, describing the traffic pattern and all vessels involved, along with installation data and weather data. The model output is the probability of a vessel collision with a stationary installation, along with corresponding total impact energies.

AIS has been the data source most commonly used to document ship traffic since its introduction (Since January 1st 2005 IMO regulations require AIS to be fitted aboard all ships of 300 gross tonnage (GT) and upwards engaged on international voyages, all passenger ships irrespective of size, and cargo ships of 500 GT and upwards not engaged on international voyages [16]). AIS data is perfect for vessel traffic studies, as it is a de facto log of a ship's movement. Before the introduction of AIS, shipping patterns had to be estimated based on port logs, radar observations, visual observations and interviews with mariners and other data sources with a variable degree of uncertainty and accuracy. Establishing shipping patterns and traffic levels provides the basis for a quantitative risk assessment to be performed later. By grouping traffic into shipping lanes and calculating the corresponding attributes, such as lateral distribution, passing distance and standard deviation, it is possible to perform a location specific analysis, and not only a generic evaluation of a large area. Another benefit of the AIS system is that with each data point comes a small "business card" with information, one of which is the vessel's Maritime Mobile Service Identity (MMSI) number. This is a unique identifier that can be linked to a more comprehensive set of attributes for each individual ship/track by connecting to a ship database. This forms the basis for a quantitative collision risk assessment. AIS data has enabled the continued use of the COLLIDE risk model, which initially used a semi-static grid of estimated shipping lanes between ports around the North Sea and Norwegian Sea. The methodology of aggregating ship traffic into routes is still considered valid, and is used by several academic and commercial actors for ship collision studies [17]. The use of AIS data has greatly improved the overall accuracy and validity of the input data used by the COLLIDE risk model.

The COLLIDE risk model is made up of several large fault trees with a fairly simple equation tying it all together. The top level equation (1) calculating the annual probability of collisions from passing vessels and other parameter descriptions are shown below [18]:

$$P_{CPP} = \sum_{i=1}^{m}\sum_{j=1}^{6}\sum_{k=1}^{n} N_{ijk} \sum_{l=1}^{4}\left[P_{CC,jkl} \times P_{FSIR,jkl} \times P_{FPIR,jkl}\right] \tag{1}$$

i = 1, 2, 3, … m k = 1, 2, 3, … n
j = 1, 2, 3, 4, 5, 6. l = 1,2,3,4.

Where m is the number of shipping lanes/routes identified to pass the installation within a relevant distance, j is the six types of vessel categories (merchant vessels, fishing vessels, offshore standby vessels, offshore supply vessels, shuttle tankers, submarines), k is the size group based on the type of vessel and l is the four traffic groups (“unknown”, “non-planning”, “position-fixing” & “avoidance” (last two both subgroups of “planning”)) used to model the navigational behavior of the vessels.

P_{CPP} = Annual probability of collisions from powered passing vessels
N_{ijk} = Annual number of vessels of type j and size k passing the installation in route i
$P_{CC, jkl}$ = The probability that a vessel of type j in size group k and traffic group l travelling in route i is on a collision course at the point when the vessel should be able to observe the installation visually or on radar.
$P_{FSIR, jkl}$ = The probability that the vessel itself does not initiate action to avoid a collision with the installation (Failure of Ship Initiated Recovery)
$P_{FPIR, jkl}$ = The probability that the installation or its external resources do not succeed in diverting the vessel on collision course, given that the vessel has not initiated such action itself (Failure of Platform Initiated Recovery)

“unknown”	The vessel in not aware of the existence of the installation prior to arriving on location
“non-planning”	The vessel is aware of the installation before arriving on location, but does not take any deliberate steps to avoid it during navigation planning
“planning”	The vessel is actively using the installation for navigation planning, either by planning to avoid it, or by using it for position-fixing

2.1. Traffic pattern

The first component (N_{ijk}) of Equation (1) is not really modeled, but simply is the result of traffic pattern assessment. AIS data is processed to determine traffic patterns and the tracks are linked to ship databases to retrieve additional data on type, size and other relevant information. All the data used to determine this variable are actual historical data and ship specifics. The aggregation and grouping of individual tracks/raw data into traffic patterns of shipping lanes may introduce some level of subjectivity and inaccuracy. Variations in methodology or subjective evaluation may lead to small differences in standard deviation, passing distance and other route attributes. The model assumes that all routes have a normal distribution in the lateral direction.

2.2. The probability of being on a collision course

The next component of Equation (1) is the probability that a vessel is on a collision course, P_{CC}. This parameter is mainly calculated based on the way the vessel is assumed to navigate, with the following set of equations: [18]

$$P_{CC1} = (1 - P_K) \times F_{D,1} \times F_{NS} \tag{2}$$

$$P_{CC2} = P_K \times \left(1 - P_{P,A}\right) \times \left(1 - P_{P,PF}\right) \times F_{D,2} \times F_{NS} \tag{3}$$

$$P_{CC3} = P_K \times \left(1 - P_{P,A}\right) \times P_{P,PF} \times F_{D,3} \times F_{NS} \tag{4}$$

$$P_{CC4} = P_K \times P_{P,A} \times F_{D,4} \times F_{NS} \tag{5}$$

P_{CC} = Annual probability of a vessel being on collision course at a distance of 12 nm
1 signifies unknown vessel (vessel unaware of the existence of the installation)
2 signifies non-planning vessel (vessel has not pre-planned evasive action)
3 signifies position-fixing vessel (vessel passing closer to help position-fixing)
4 signifies avoidance vessel (vessel taking evasive action to increase distance)

p_K = probability of vessel being aware of the existence of the installation
$p_{P,A}$ = probability of vessel planning evasive action

$p_{P,PF}$ = probability of vessel using installation for position-fixing
$F_{D,I}$ = fraction of vessels heading towards the installation
F_{NS} = shielding factor

Several factors above are the product of more detailed subroutines, but how these are calculated will not be addressed in this paper.

2.3. Failure of ship initiated recovery

The P_{FSIR} component of Equation (1) is calculated from a fault-tree, and the COLLIDE project identified three main modes of failure:

- Watchkeeping/navigation failure/failure to act
- Erroneous action by navigator
- Equipment failure/technical error

The last two items were considered negligible by the COLLIDE project, with the exception of a radar failure. The argument was that equipment failure that would lead to a collision was highly unlikely and should be disregarded. Similarly, the action needed to avoid collision was simply to alter course, an action deemed so simple that erroneous action was highly unlikely and thus disregarded.

The first item however, was further broken down, to the following list:

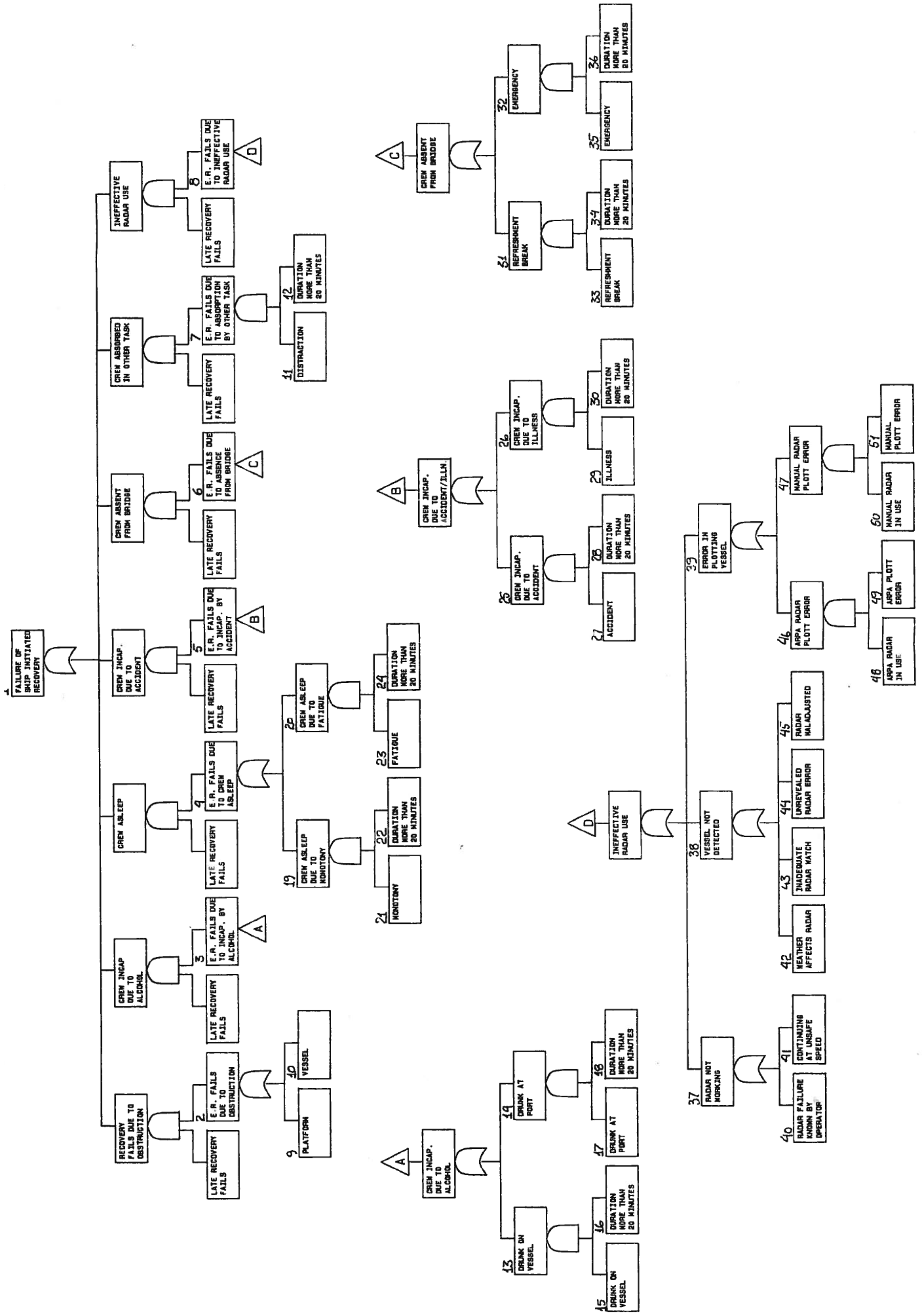
- Watchkeeper/navigator absent (from bridge)
- Watchkeeper/navigator distracted/absorbed by other task(s)
- Watchkeeper/navigator incapacitated
- Watchkeeper/navigator asleep
- Watchkeeper/navigator incapacitated/asleep due to alcohol
- Radar navigation failure (only applicable in bad visibility)

The fault tree shown in Figure 1 models the P_{FSIR} (Failure of Ship Initiated Recovery) component (limited to watchkeeping/navigation failure / failure to act) in the COLLIDE model. However, the COLLIDE project additionally describes a set of factors that influence the P_{FSIR} component, without being a part of the actual fault tree. The first of these is the meteorological parameter of visibility. The COLLIDE model is using two different fault trees for the P_{FSIR} component, one for good visibility and one for bad visibility, in order to account for the level of visibility. The COLLIDE project mentions several other influencing factors, but only two others are quantified and incorporated into the model. These are a ship's flag state and the activity level in the area of interest. It is argued that a ship's flag state may have an influence on the probability of watchkeeping/navigation failure / failure to act, as various flag states may have significantly different loss statistics, indicating poor standards or safety culture. The last of these "factors which may influence Ship Initiated Recovery" is the general activity in the area. An area with heavy congestion from other ships, or multiple offshore installations perhaps with a fleet of offshore vessels performing various tasks undoubtedly complicates the traffic situation. The project describes how an evasive maneuver may put vessels on a collision course or at least negatively influence the passing distance between the vessel and the installation [18].

2.4. Failure of platform initiated recovery

The last component of Equation (1) is the P_{FPIR} component. It is also the result of a fault-tree, considering factors such as realization that a vessel may pose a threat, establishing successful communication with the vessel and having the standby vessel to intercept. The efficiency and success of platform initiated actions will be highly dependent on the reasons behind a failure of ship initiated recovery, but this topic is not explained in great detail in the COLLIDE project; instead it references the RABL project.

Figure 1: Fault tree for probability of failure for ship initiated recovery in bad visibility [18]



The fault tree shown in Figure 1 was heavily influenced by work done in the RABL project [4].

3. DISCUSSION

The COLLIDE risk model was a joint venture between academia and the offshore oil and gas industry from the very beginning, so the risk model was made into a software program immediately after its conception. Soon it became the industry standard for collision risk assessments on the Norwegian Continental Shelf (NCS). An independent validation of the model and software was performed shortly after its introduction to ensure that it reflected historical data with regard to passing vessel collision frequencies. The validation project had COLLIDE predicting 3.8 collisions for the timeframe in question, and at the end of the validation period, 3 collisions had been recorded. Another collision was observed the following year. These results indicated good correlation between the collision frequency estimations from the risk model and historical data of actual events [1]. It should be noted that the validation was done for the average collision risk across all installations within the validation area, and not for specific installations.

Since 1995, much has happened in the offshore oil and gas industry, in maritime shipping and with respect to general technological innovation and progress. A large part of the basic methodology and core calculations remain valid today, as there is little change in the most basic elements. However, a lot has changed for a significant portion of the factors and variables making up the model, and a static framework is not able to adapt well enough to changes of this type. Weather data and ship and offshore installation size, shape and geometry can only change marginally, and does not affect the methodology, as these factors have always been input variables submitted by the user. Assumptions and thought-processes that have shaped the underlying fault trees or that may invalidate important elements of the calculation if no longer representative of real world behavior are more problematic.

Critics of the COLLIDE risk model claim that the level of details and number of variables introduce too much uncertainty, and argue for a more simplistic approach with fewer variables largely based on historical data and expert judgment. The number of variables may indeed introduce uncertainty, but having a detailed model allows for a better understanding of influencing factors, at least in a qualitative sense, and the possibility to see the effect of individual variables. The uncertainty may be reduced by using distributions, grouping values into categories or high/low scoring instead of a set of static values. Using statistical data is not void of uncertainty [19], and may not always provide the best alternative for input data. Statistical data also come with a set of inherent implications, such as the future being a linear continuation of the past. If quantification of input data can be done well, in order to limit uncertainty, a detailed model with a wide range of variables is arguably preferable, as it enables a wider set of evaluations and results, including the effect of risk reducing measures.

3.1. Traffic pattern

The traffic pattern serves as the core input to the COLLIDE risk model when estimating collision risk frequencies, and since it is now based on AIS data, the data quality is good. There are many ways to model vessel movement, but the COLIDE model is (currently) not doing anything with the data other than aggregating tracks into routes, and then calculating the actual distribution parameters, such as passing distance and standard deviation. The details of how to model the traffic pattern is a separate discussion outside the scope of this paper. However, it is worth mentioning that since the traffic pattern is presented “as-is” without any further modifications, (for new installations not yet on the scene) it really is the historical statistical picture of an area before the introduction of an installation, and this may give the illusion of a route passing straight over the installation, or extremely close. This will never be the case, and may easily be corrected by introducing a “bubble” around the position in question when performing calculations. By pushing routes outwards from the center of a position, to a minimum passing distance, one may argue that the traffic pattern will better reflect the actual pattern once an installation is in place. This kind of adjustment may also be based on observations of traffic in vicinity of existing installations. This is something that is done by analysts today, but it is regarded as a sensitivity[‡] to the original analysis, and only done on request. Risk modeling should always present expected values from a conservative point of view, but making a simple adjustment to better reflect the predicted future pattern should be considered the new norm when introducing installations where none existed at the time of the analysis.

3.2. The probability of being on a collision course

The probability that a vessel is on a collision course is one of the items that the COLLIDE project focused on, and the final model (of P_{CC}) is a result of extensive interviews and research. However, the current way navigation is being performed is markedly different than 20 years ago. P_{CC} is arguably mostly a "geometric"/deterministic factor, based on the traffic pattern and its routes distribution and parameters. The COLLIDE risk model's set of calculations (Equations 2-5) bases its logic on the assumption that knowledge of the installation's presence prior to arrival on location will influence the probability of being on collision course, on several levels. Some ships will intentionally have a higher probability as they may use the installation as an object for position fixing, while others may be blissfully unaware of the installation in the first place. Without presenting an updated solution to this factor, the authors agree that the current logic and model no longer reflect the current way a navigator deals with this type of issue, regardless of the installation's presence being known or not prior to arrival to the area. Avoiding obstacles not prior known is a common occurrence for navigators, and an integral part of the act of navigating. An update of the COLLIDE model should as a minimum conduct interviews with current navigators to investigate the validity of the old model, and perhaps get a better idea of how to improve the model based on new information. The probability of a ship being on a collision course can easily be treated as a "geometric"/deterministic factor, and all other considerations regarding navigation skill and performance involving human (inter)action can be included elsewhere in the model in order to structure the different factors and variables better.

3.3. Failure of ship initiated recovery

The art of navigation is dynamic and constantly changing as new tools and navigation aids are introduced. When the COLLIDE risk model was first made, it was not uncommon for some navigators to use offshore installations as visual waypoints and guides to aid them with position fixing. With new technology being developed and becoming standard equipment or made mandatory by (inter)national regulations, the way seafarers navigate and the tools at their disposal have changed dramatically over the last 2-3 decades. As a consequence, the fault-tree in Figure 1 may no longer be a good approximation of what factors should be included, how variables influence and interact or even the best choice of method.

The P_{FSIR} component is using a fault tree to model something as complex as human behavior in a very complex setting, the navigation-bridge on a ship. The COLLIDE model has been validated with the current assumptions and framework, but assuming that additional elements are needed and/or some of the assumptions are no longer valid the fault-tree model fast becomes less than optimal. It would make more sense with a hybrid fault-tree/risk influencing factor (RIF) structure, or perhaps a Bayesian belief network (BBN) as discussed by Truccoa et al. [20]. The current model uses RIFs to some degree already. A vessel's flag state may indeed be an influencing factor on a ship's overall quality and influence the probability of navigation errors. However, if flag state is to be a performance metric for a more comprehensive risk model, one needs to have current data on high and low quality flag states, as this is a dynamic factor that changes over time. Perepelkina et al. [21] argues that the Black/Grey/White List could be a useful metric in deciding how flag states should be ranked with regards to safety.

The current model does not have a sufficient way of incorporating such RIF's into the model, and the fault-tree in Figure 1 with the top event "watchkeeping error / failure to act" is only looking at a set of

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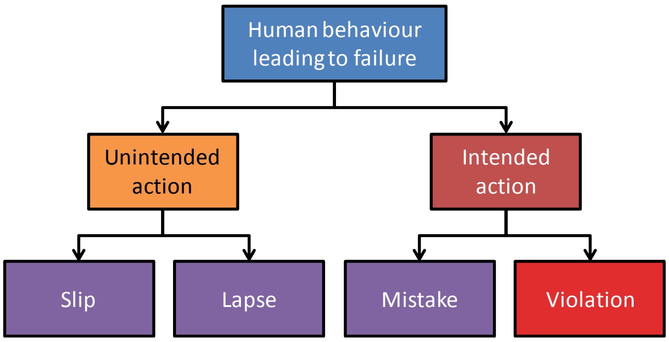
[‡] A "sensitivity" for a risk consultant is an addition to a risk assessment, where one or more variables have been changed, usually to check some kind of "what-if" scenario.

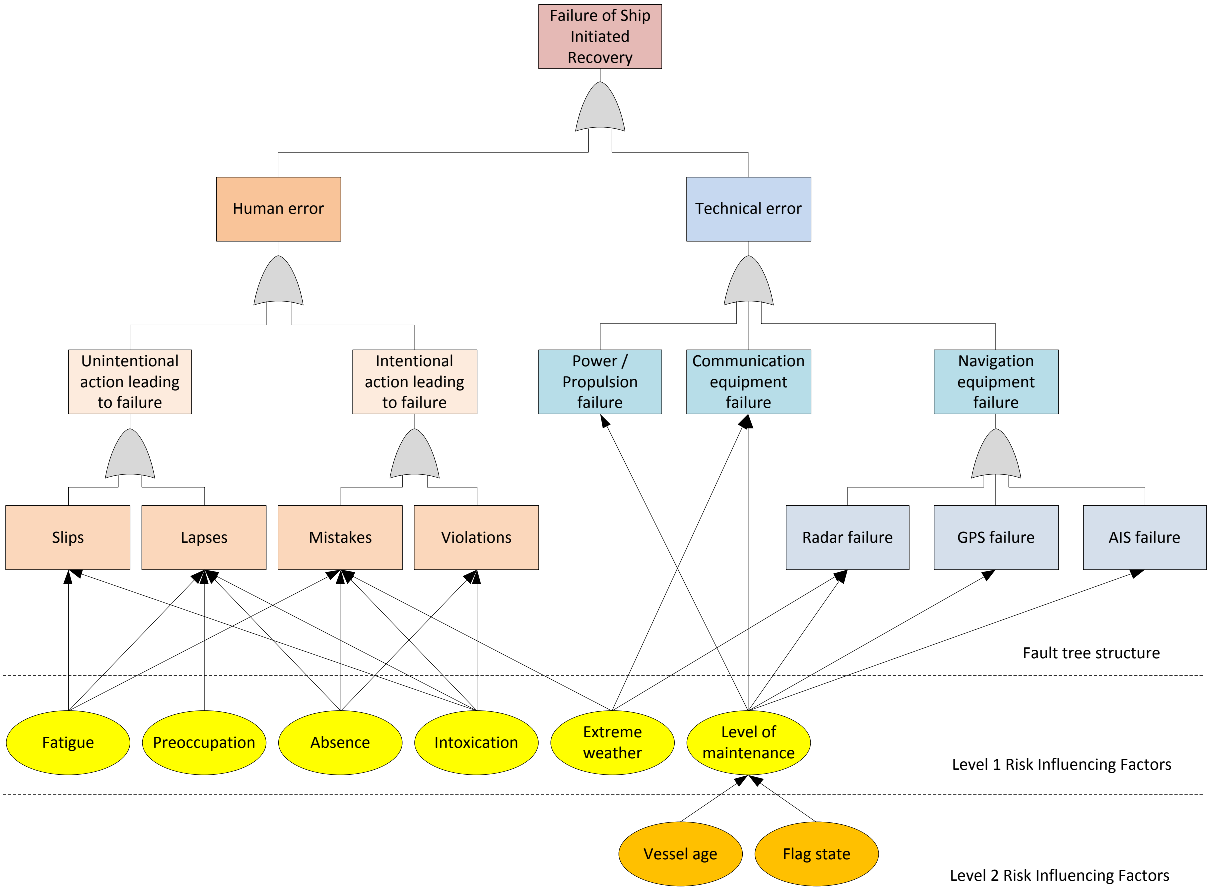
scenarios where the navigator is incapacitated in some way or form. There is no mentioning of other factors that seem prudent to include. There is no real structure of the variables, whether they are errors of commission or errors of omission. That said, the model has solved this by claiming that errors of commission are negligible, leaving only errors of omission, and effectively narrowed it all down to only lapses. The current taxonomy for human errors is summed up nicely by HSE and NOPSEMA [22, 23] and a simplified illustration is shown in Figure 2.

Figure 2: Categorization of human errors [24]



A slip is just an unintended action, like pushing the wrong button, and similarly a lapse is just the unintended failure to act, such as not pressing a button. A mistake is the result of an intended action, producing an unintended result, typically an error of judgment, while a violation is the intentional act of not following a good rule. Without going into further detail, it is obvious that the COLLIDE risk model of erroneous navigation by the watchkeeping officer is oversimplified. It should include more elements, and even with a lack of good data, try to account for more factors that may influence the overall probability of failure of ship initiated recovery. An example of how this could be achieved by expanding and modifying the current fault tree to a hybrid fault tree and RIF structure is shown in Figure 3.

Figure 3: Example of hybrid fault tree and RIF structure for P_{FSIR} adapted from [25]



3.4. Failure of platform initiated recovery

The P_{FPIR} component is poorly described in the original risk model, but enough is known to see that it does not account for a wide range of barriers and tools readily available today. For example will AIS enable an installation to contact a vessel with name and callsign on VHF or through the VHF's digital selective call (DSC), or simply call the ship on normal telephone based on their AIS "business card".

Statoil has established a marine traffic surveillance center [26], monitoring all traffic to and around their installations on the NCS. A continuous and competent surveillance from a "sea traffic control tower" is a major improvement in vessel detection and intervention through communication or by tasking local standby vessels to physically intercept. In lieu of a standby vessel, helicopters have also been used to approach and intercept incoming vessels. New operational guidelines, barriers and technology have added elements and complexity that will need to be implemented and accounted for to have a good risk model.

Another aspect of today's installations not really accounted for in the current risk model, is an installation's ability to physically "get out of the way" of an incoming ship. Semi-submersibles on DP may disconnect the drill string and move, and if they are at anchor they may even drop anchor on one side and use the tension and/or winches to move an installation-width or two. FPSO/FSUs with a ship hull design are often turret-moored with weather-waning capability, meaning they may turn their bow against an incoming ship to present a smaller cross-section. All of these risk influencing factors should be considered for inclusion in the P_{FPIR} component. It can be done in the same fashion as for the P_{FSIR} component, with a revised and expanded hybrid fault tree with RIFs, or using BBN.

4. CONCLUSION

This paper has addressed the COLLIDE model and some of the challenges the current model faces. Since the COLLIDE model is fairly old and not too well known, the overall architecture and methodology has been described briefly before getting into the main components in more detail. The main findings indicate that the modeling of both the two primary components, P_{FSIR} and P_{FPIR}, are far from optimal and should be the subject of further research. The way certain factors are incorporated into the risk model without being a part of the main fault trees indicate that a hybrid fault-tree and RIF structure model should be investigated further, as new methodology has enabled better quantification methods and ways to incorporate additional risk influencing factors without introducing additional uncertainty.

COLLIDE is currently being revised with respect to new elements that were not relevant at the time the model was first developed, and to update the methodology to better represent the way installations, and ships are being operated today. Parts of the methodology should also be revised and checked against new data and research, to investigate its current validity. Revising the complete COLLIDE risk model will be a major task and an iterative process requiring extensive data collection and risk modeling, but it will ultimately improve the way risk is modeled, estimated and mitigated by the offshore oil and gas industry in Norway. A more elaborate and up to date methodology will also enable this model to work for other geographical locations.

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