University of South-Eastern Norway

Europe-Korea Conference on Science and Technology (EKC2021)

Autonomous Ship Safety

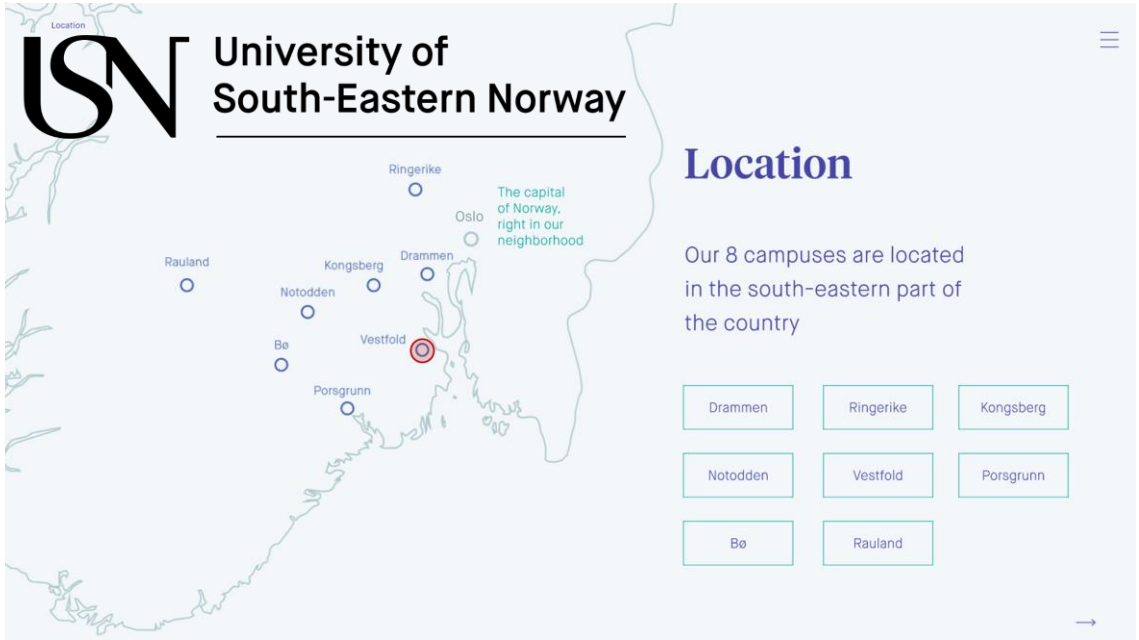


24.10.2021

Associate Professor Hyungju Kim

EKC 2021
Europe-Korea Conference on Science and Technology

University of South-Eastern Norway



NTNU
Det skapende universitet



SAMSUNG
HEAVY INDUSTRIES



18.230 STUDENTER

1.900 ANSATTE

BA 65 BACHELOR-UTDANNINGER

MA 36 MASTER-UTDANNINGER

PhD 8 DOKTORGRADS-PROGRAMMER

8 CAMPUSER

BØ – DRAMMEN – KONGSBERG
NOTODDEN – PORSGRUNN
RAULAND – RINGERIKE – VESTFOLD

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Lectures

- HTOI (Human, Technology, Organization and Innovation) – PhD course
- Risk analysis for autonomous systems – master course
- Marine machinery and green ship technologies – master course
- Introduction to Autonomy – master course
- Maintenance management and reliability engineering – bachelor course

Projects

A.WILHELMSEN FOUNDATION

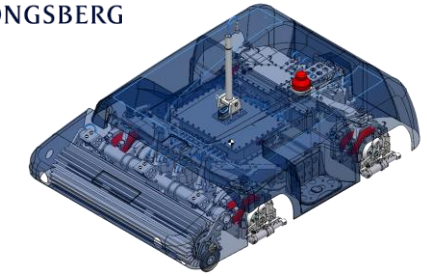




AUTOSTRAIF



KONGSBERG



SAMS Norway



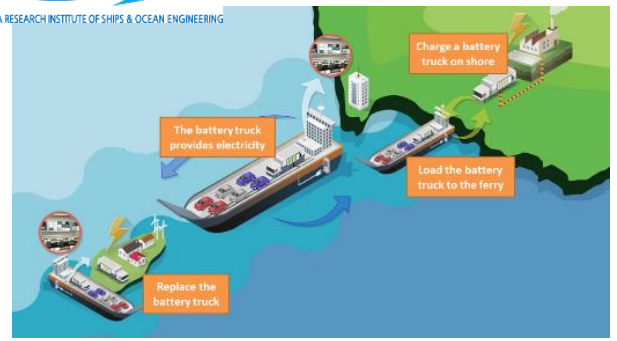
MARITIME ROBOTICS



KR KOREAN REGISTER



KRISO
KOREA RESEARCH INSTITUTE OF SHIPS & OCEAN ENGINEERING



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Contents

1. Autonomous Ship Safety Guidelines in Norway
2. New Safety Analysis Methods
    1. Systems-Theoretic Process Analysis
    2. Real-time Risk Analysis
3. Summary

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Autonomous Ship Safety Guidelines in Norway

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Autonomous Ship Reality in Norway!

CNN World

TRADERS

World's first crewless, zero emissions cargo ship will set sail in Norway

By Rochelle Beighton, CNN

Updated 1903 GMT (0303 HKT) August 27, 2021



Photos:

The Yara Birkeland is what its builders call the world's first zero-emission, autonomous cargo ship. The ship is scheduled to make its first journey between two Norwegian towns before the end of the year. **Click through to see more forms of transport set to transform the future.**

OCEAN AUTONOMY CLUSTER

Will this be the world's first electric and autonomous city ferry?

Published: February 19, 2021

The city of Kristiansund may be the first city in the world to have an autonomous passenger ferry.



Illustration: Møre Maritime and K8 Industridesign.

"Sundbåten" in the Norwegian coastal city of Kristiansund, is the world's oldest public transport company still in operation, established in 1876. In 2023, it may also be the world's first of its kind with an electric and autonomous urban passenger ferry, reports TU.no (Norwegian).

Safety…



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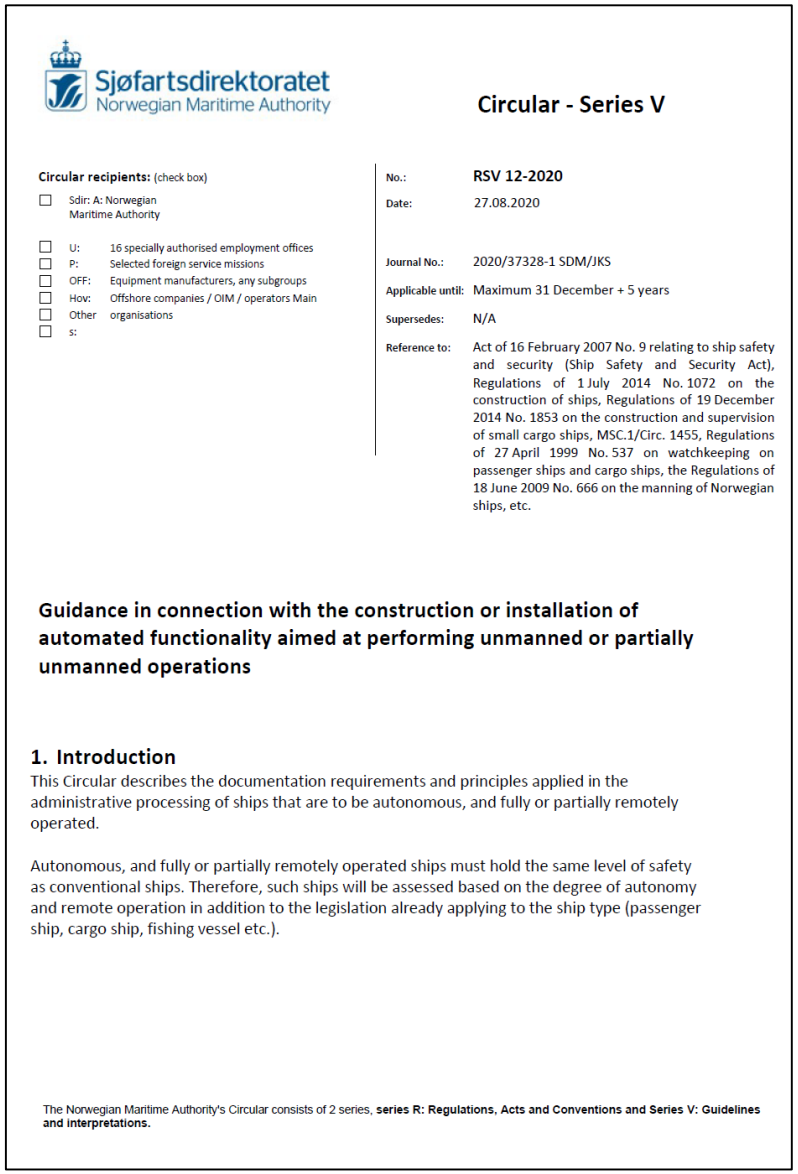
Autonomous Ship Safety Guideline of NMA



Sjøfartsdirektoratet
Norwegian Maritime Authority

Circular - Series V

Circular recipients: (check box)

- ☐ Sdir: A: Norwegian Maritime Authority
- ☐ U: 16 specially authorised employment offices
- ☐ P: Selected foreign service missions
- ☐ OFF: Equipment manufacturers, any subgroups
- ☐ Hov: Offshore companies / OIM / operators Main
- ☐ Other organisations
- ☐ s:

No.: RSV 12-2020
Date: 27.08.2020

Journal No.: 2020/37328-1 SDM/JKS
Applicable until: Maximum 31 December + 5 years
Supersedes: N/A
Reference to: Act of 16 February 2007 No. 9 relating to ship safety and security (Ship Safety and Security Act), Regulations of 1 July 2014 No. 1072 on the construction of ships, Regulations of 19 December 2014 No. 1853 on the construction and supervision of small cargo ships, MSC.1/Circ. 1455, Regulations of 27 April 1999 No. 537 on watchkeeping on passenger ships and cargo ships, the Regulations of 18 June 2009 No. 666 on the manning of Norwegian ships, etc.

Guidance in connection with the construction or installation of automated functionality aimed at performing unmanned or partially unmanned operations

1. Introduction

This Circular describes the documentation requirements and principles applied in the administrative processing of ships that are to be autonomous, and fully or partially remotely operated.

Autonomous, and fully or partially remotely operated ships must hold the same level of safety as conventional ships. Therefore, such ships will be assessed based on the degree of autonomy and remote operation in addition to the legislation already applying to the ship type (passenger ship, cargo ship, fishing vessel etc.).

The Norwegian Maritime Authority's Circular consists of 2 series, **series R: Regulations, Acts and Conventions and Series V: Guidelines and interpretations.**

		MSC.1/Circ. 14552020.	*RSV*
1. Preliminary Design		4.5	
	1.1 Concept of operation - CONOPS	4.5	7.1
	1.2 Pre-HAZID		7.2
	1.3 Safety philosophy		7.3
	1.4 Design philosophy		7.4
	1.5 Operation and maintenance philosophy		7.5
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	2.2 Risk analyses/assessments		7.2
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	2.3 HAZID and risk assessments		7.9
3. Analysis of final design		4.1	
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4. Performance approval tests & analyses		4.1	
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https://www.sdir.no/en/shipping/legislation/directives/guidance-in-connection-with-the-construction-or-installation-of-automated-functionality-aimed-at-performing-unmanned-or-partially-unmanned-operations/

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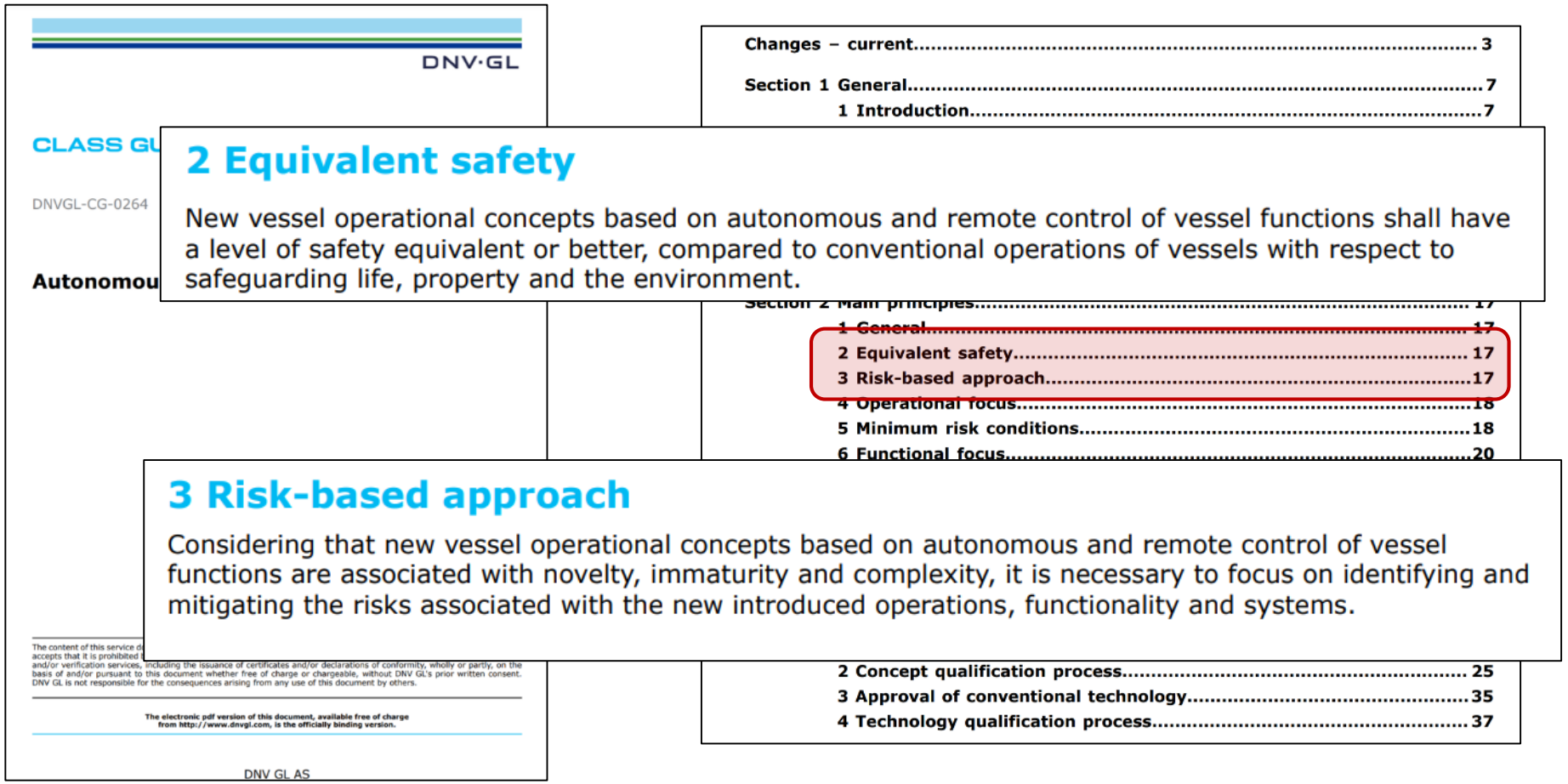
Autonomous Ship Safety Guideline of DNV



https://rules.dnv.com/docs/pdf/DNV/cg/2018-09/dnvgl-cg-0264.pdf

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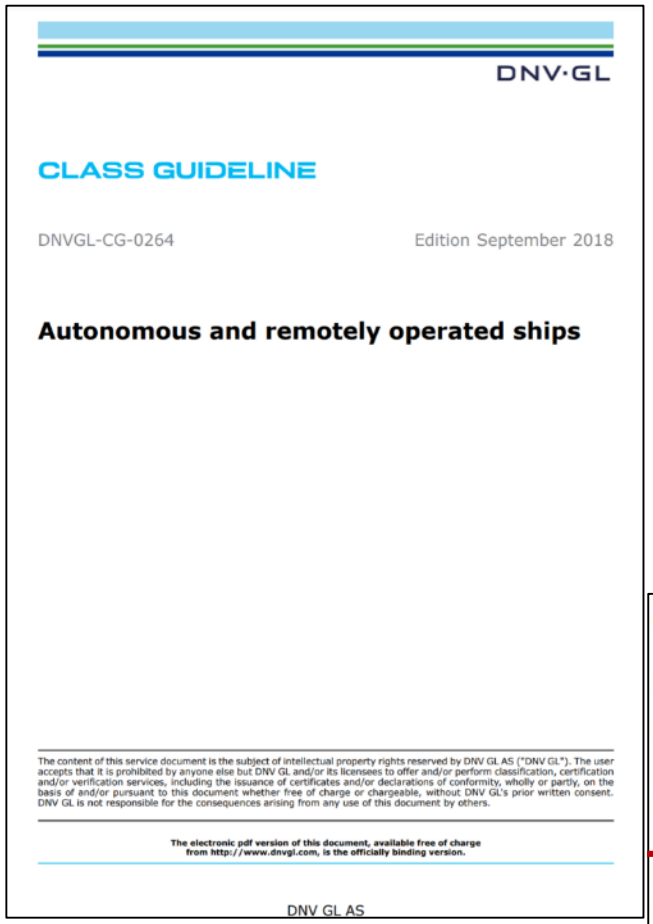
Autonomous Ship Safety Guideline of DNV



DNV·GL

CLASS GUIDELINE

DNVGL-CG-0264 Edition September 2018

Autonomous and remotely operated ships

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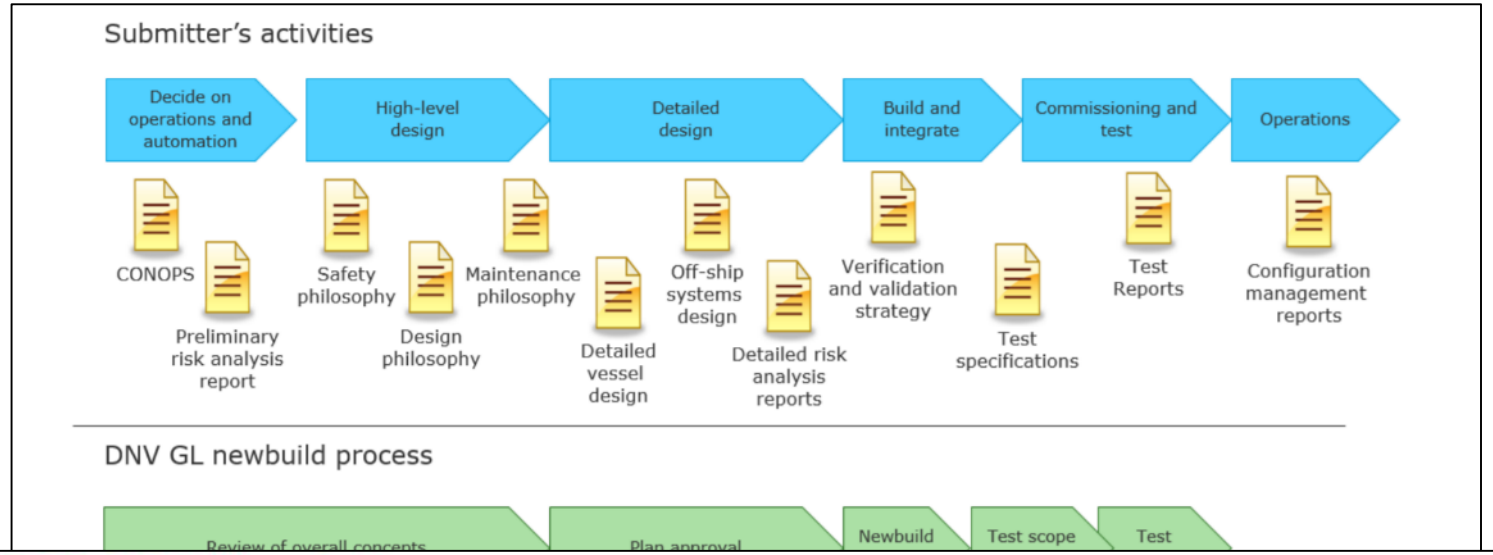
DNV GL AS

https://rules.dnv.com/docs/pdf/DNV/cg/2018-09/dnvgl-cg-0264.pdf



2.5.3 Detailed risk analysis

A detailed risk analysis of autoremote systems in total should be performed on basis of CONOPS, safety philosophy, design philosophy, off-ship systems design and vessel design information. The purpose is to ensure that the autoremote infrastructure as a whole is able to deal with relevant failures and situations in safe manner.

The risk analysis should be performed using one or more established risk analysis methods such as fault tree analysis (FTA), event tree analysis (ETA) or failure mode and effects analysis (FMEA).

Functions and systems for autoremote functionality are expected to be able to handle a number of failure modes. Some of the situations and failure modes may be project specific. In addition, the technical guidance sections in this guideline lists a number of hazards, incidents and failure modes with expected responses that should be taken into consideration in the detailed risk analysis.

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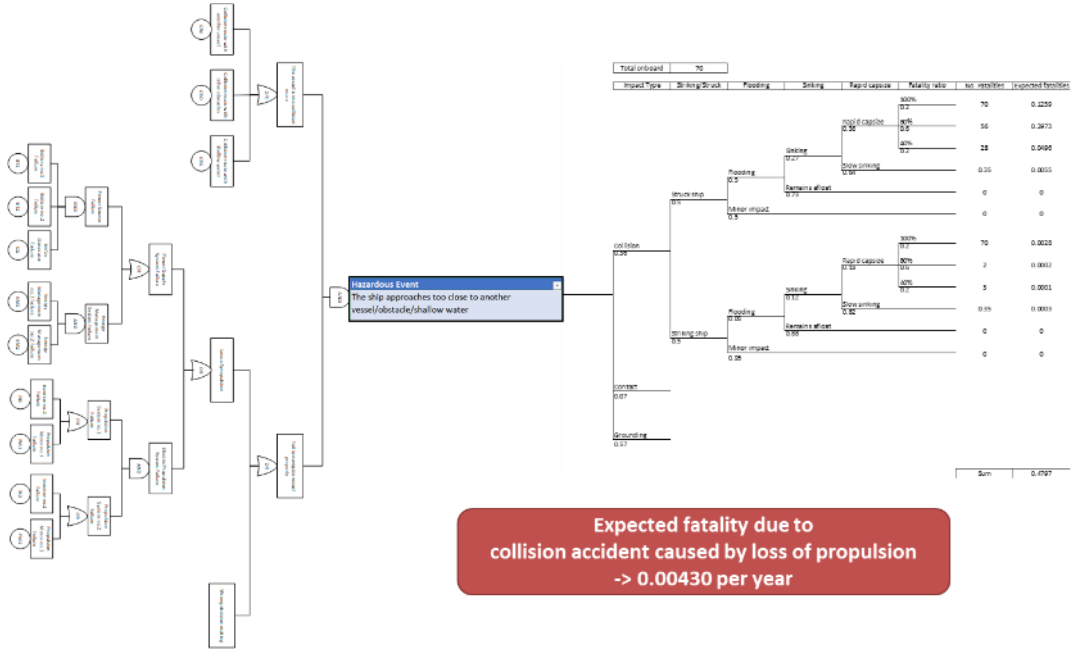
Challenges of Established Risk Analysis Methods



- Uncertainty

  - assumptions, incorrect values/models, various databases, ...
- Accidents and failures are too rare (not enough data)
- Accidents without failures (complex interaction, …)
- Software errors
- Average failure probability

  - data from various systems/condition/lifecycle, …

Assumption no.1
Failure rate is constant over time, application, manufacturer, operator, etc.

Assumption no.2
Non-repairable item

Assumption no.3
As good as new after maintenance

Assumption no.4
Failure probability is exponentially distributed

Assumption no.5
All items are independent with each other

Assumption no.6
Other minor components are negligible

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Autonomous Ship Safety

New Analysis Methods

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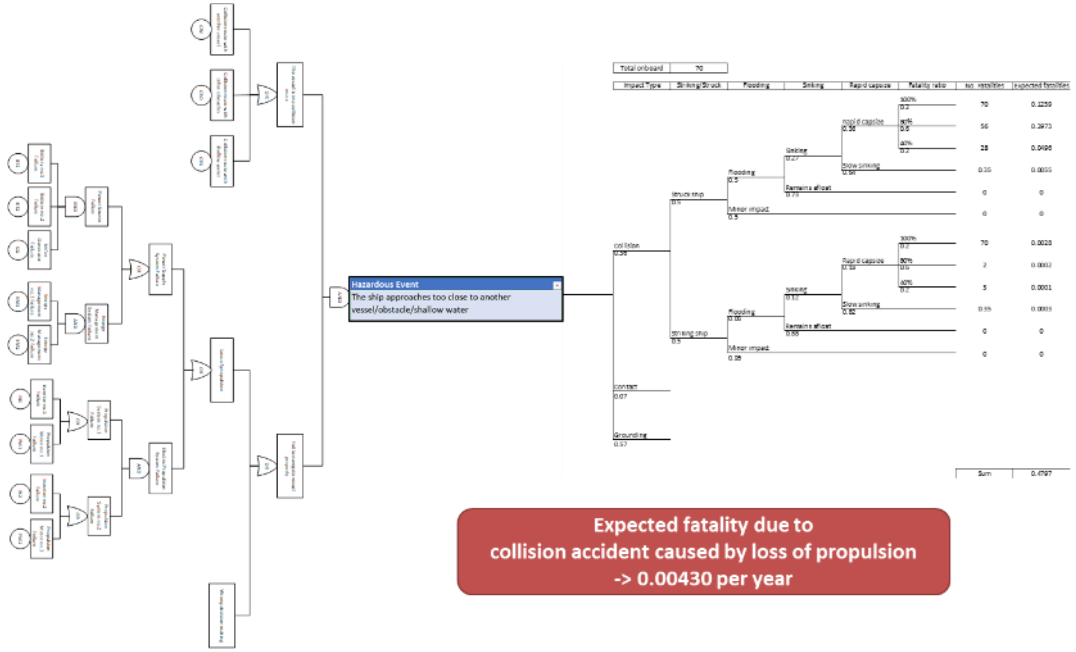
Challenges of QRA (PRA)



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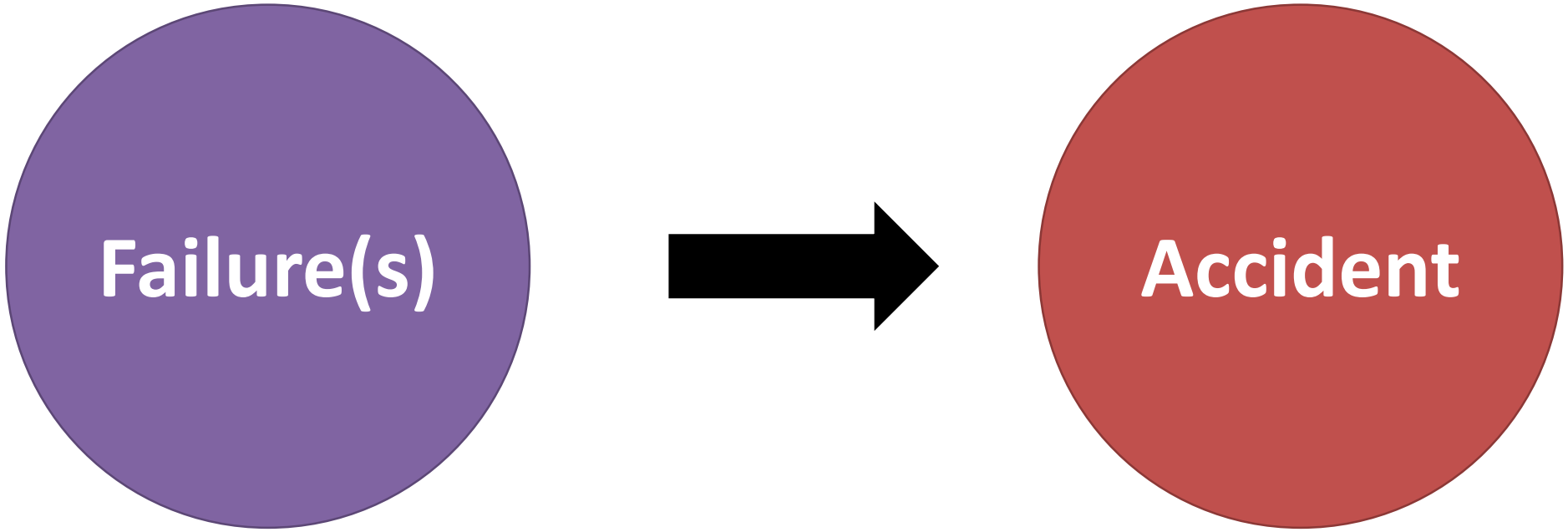
Why do Major Accidents Occur?



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Is it “still” true???







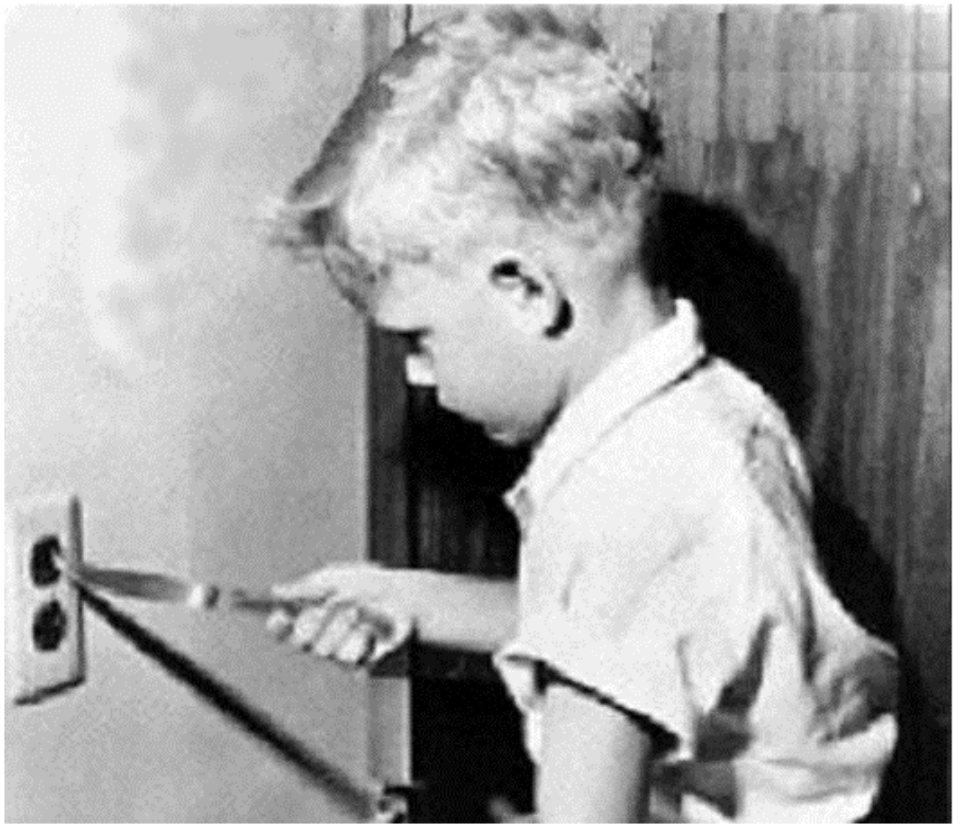


Safe or Unsafe?

Ref: Leveson N., (2019). Engineering a Safer and More Secure World

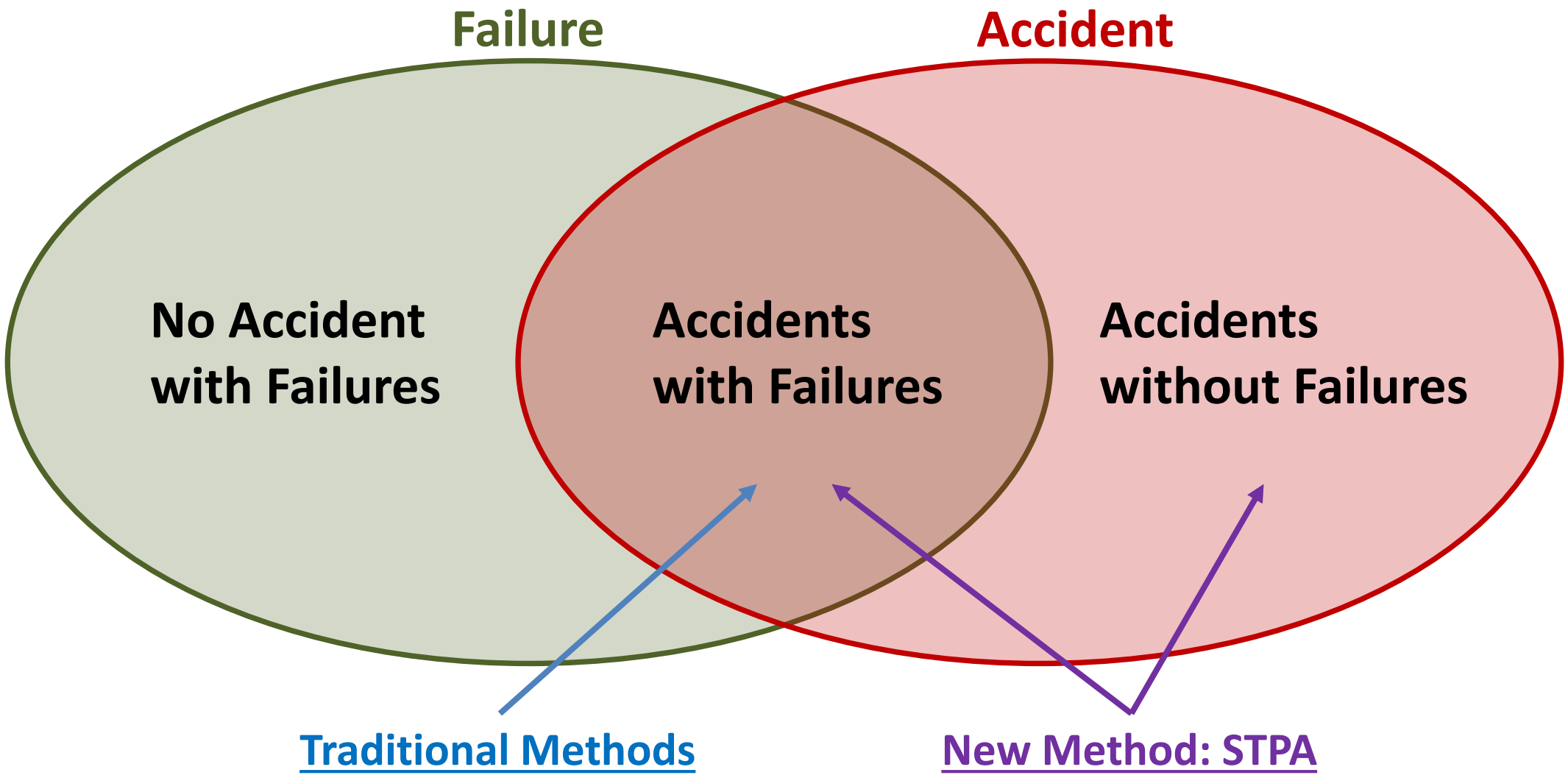
Safety Depends on Context





Ref: Leveson N., (2019). Engineering a Safer and More Secure World

Failure and Accident



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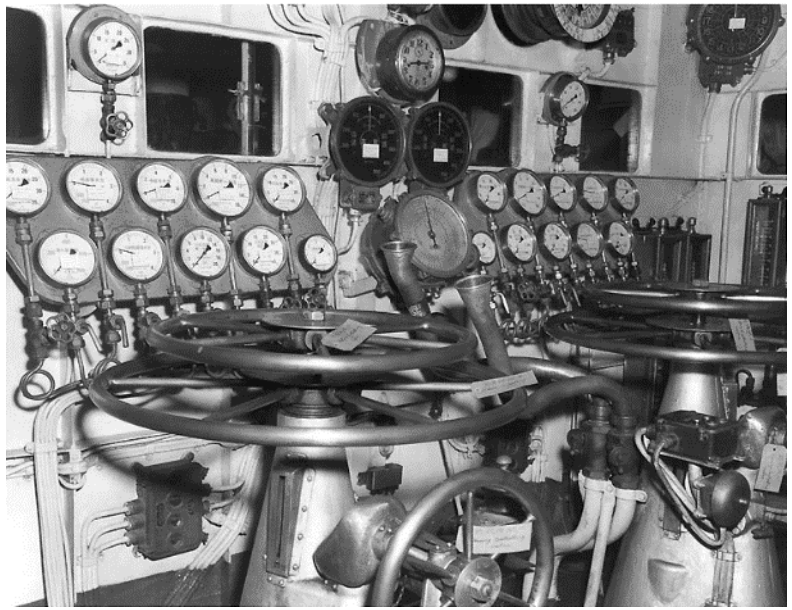
Systems-Theoretic Process Analysis (STPA)

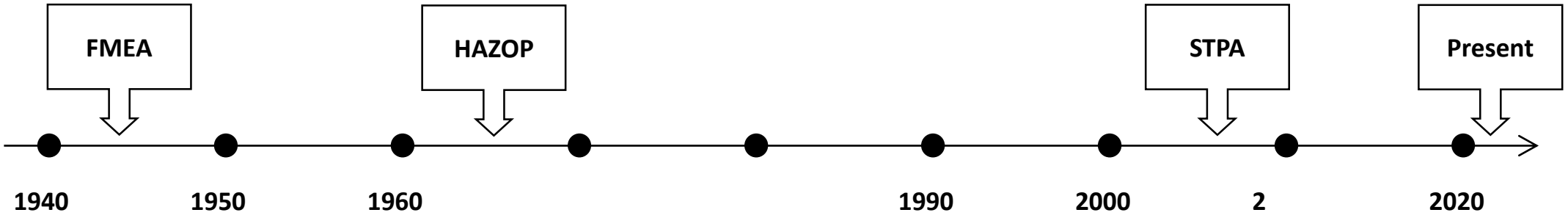
- A new hazard analysis technique based on STAMP theory
- Accidents are not “Failure Problem”, but “Control Problem”
- The main objective is to analyse unsafe control actions and loss scenarios
- Used in many different sectors and domains, but not widely used for maritime industries, yet

Why STPA?

- STPA was recently developed for modern complex systems







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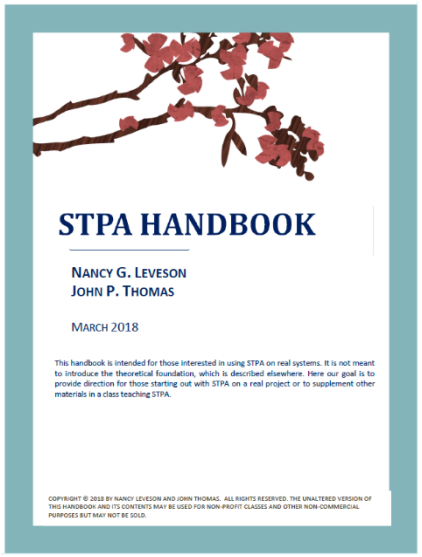

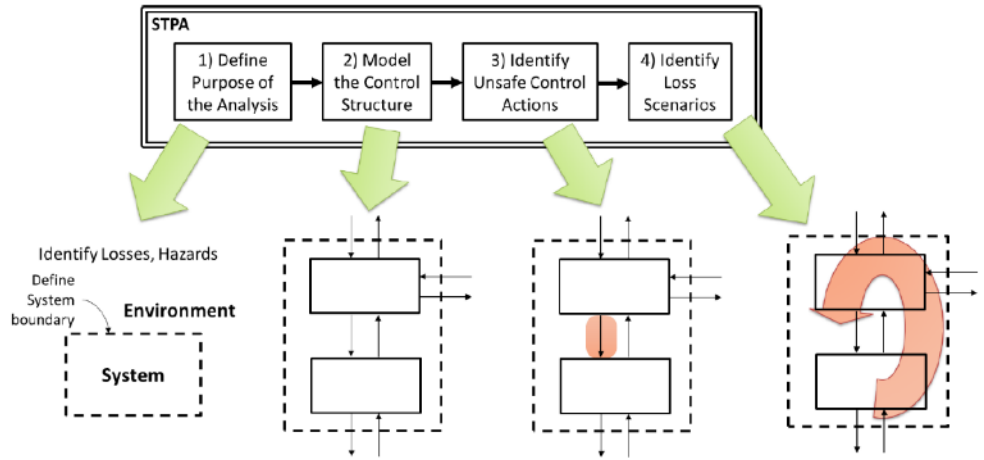

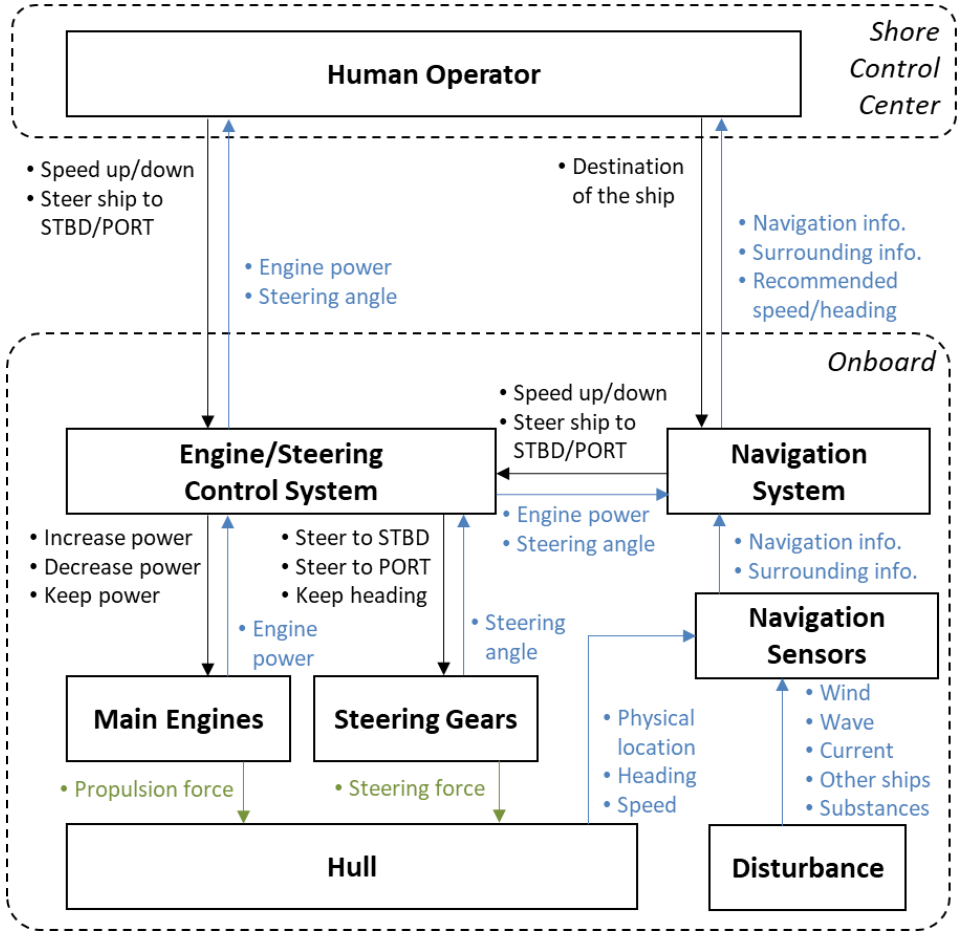

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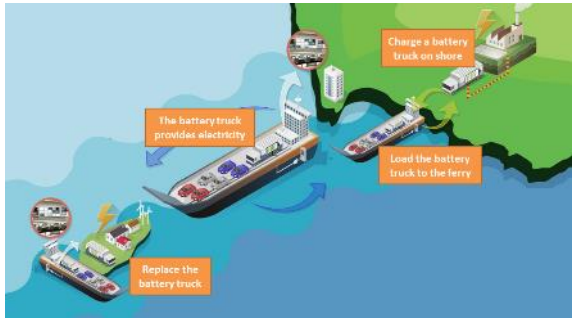
STPA Studies







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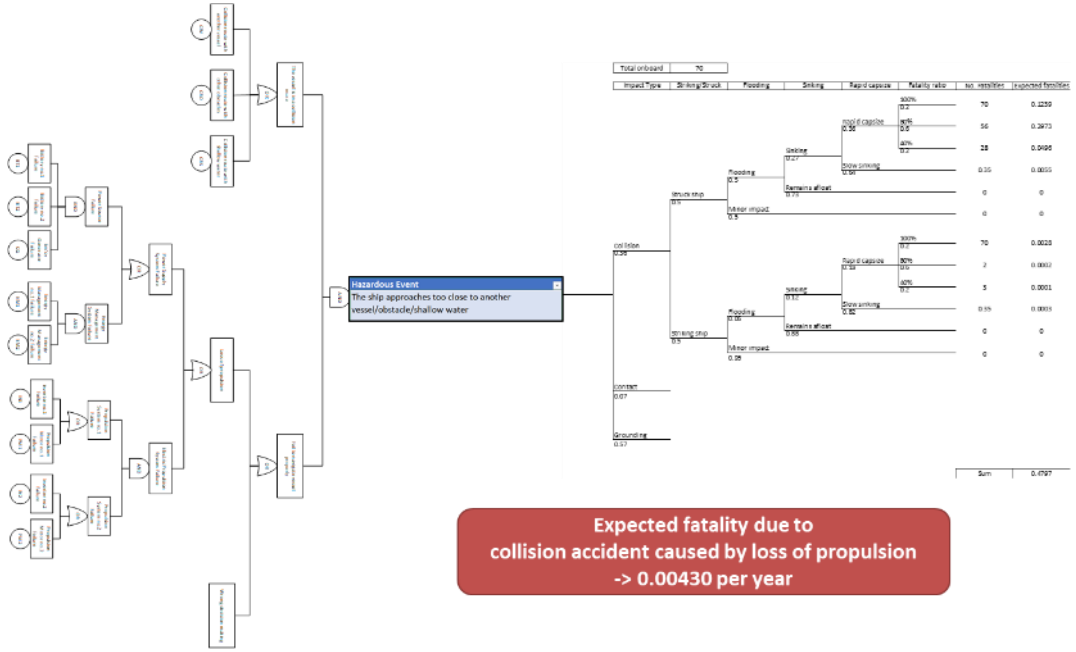
Challenges of QRA (PRA)



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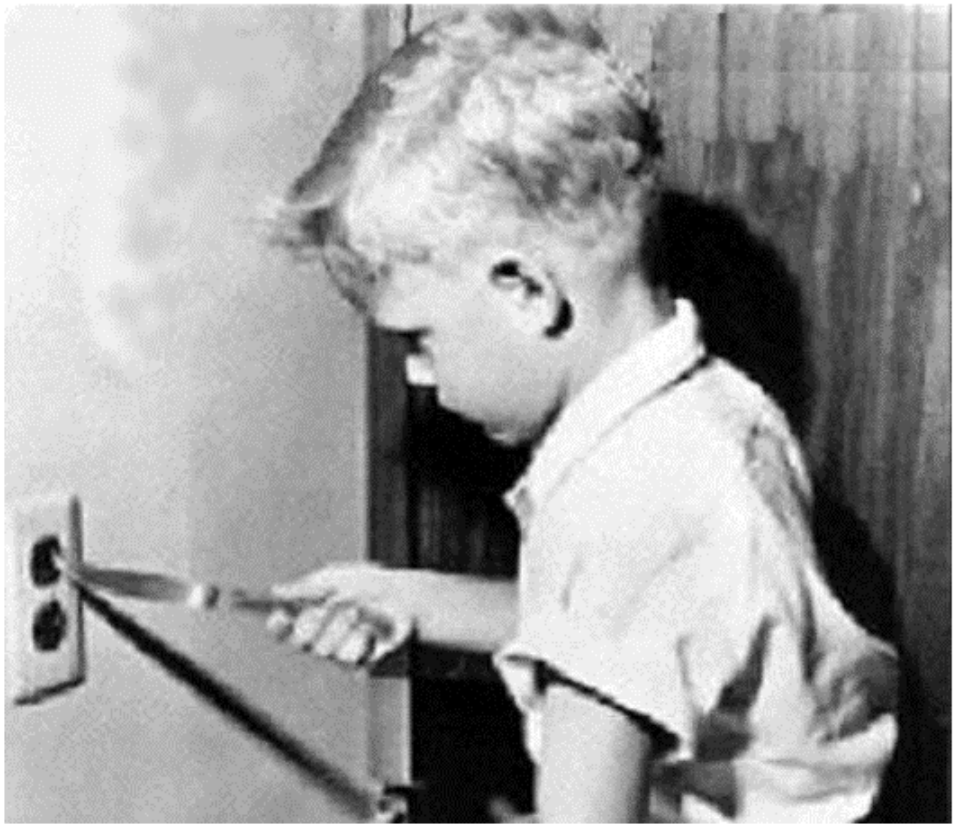
Safety Depends on Time





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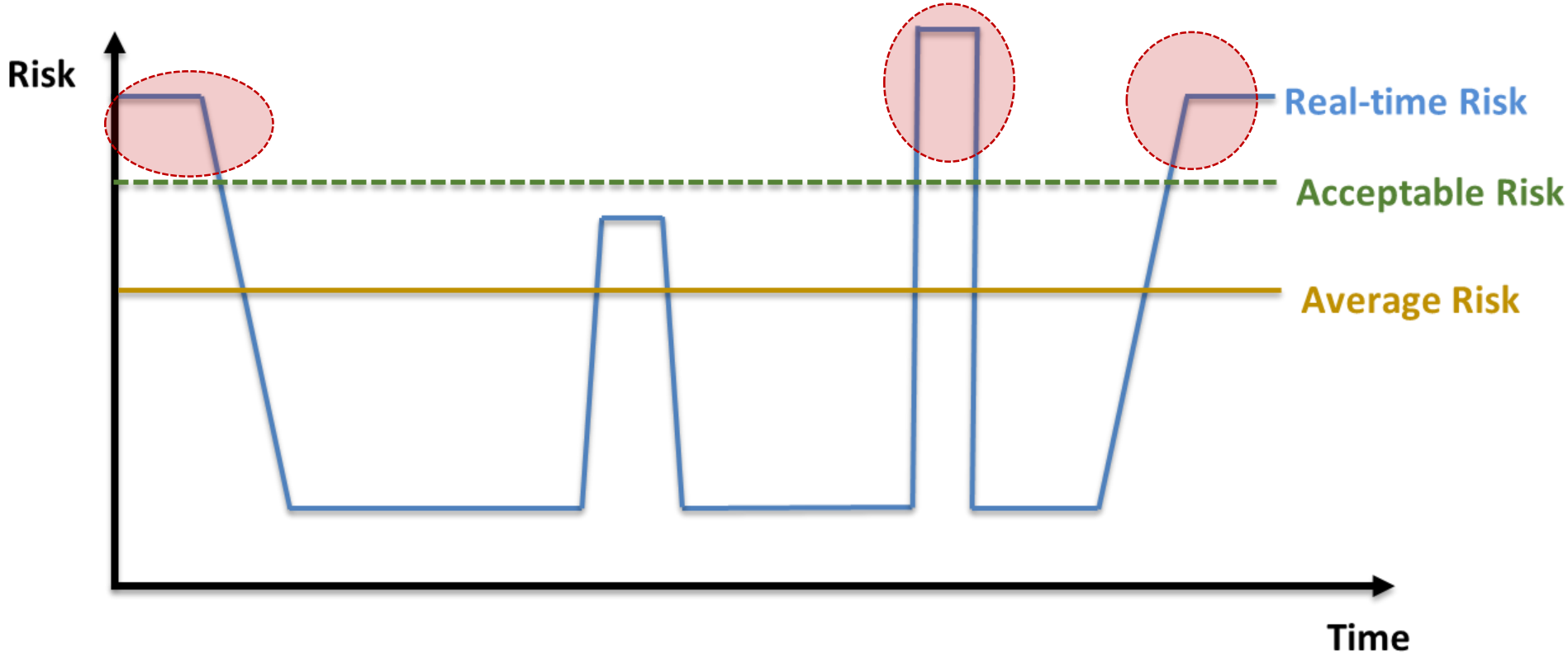
Average Risk vs. Real Time Risk



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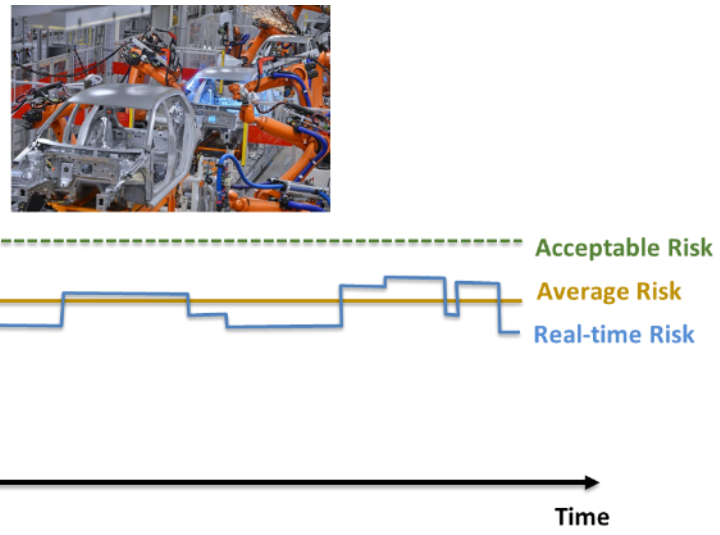

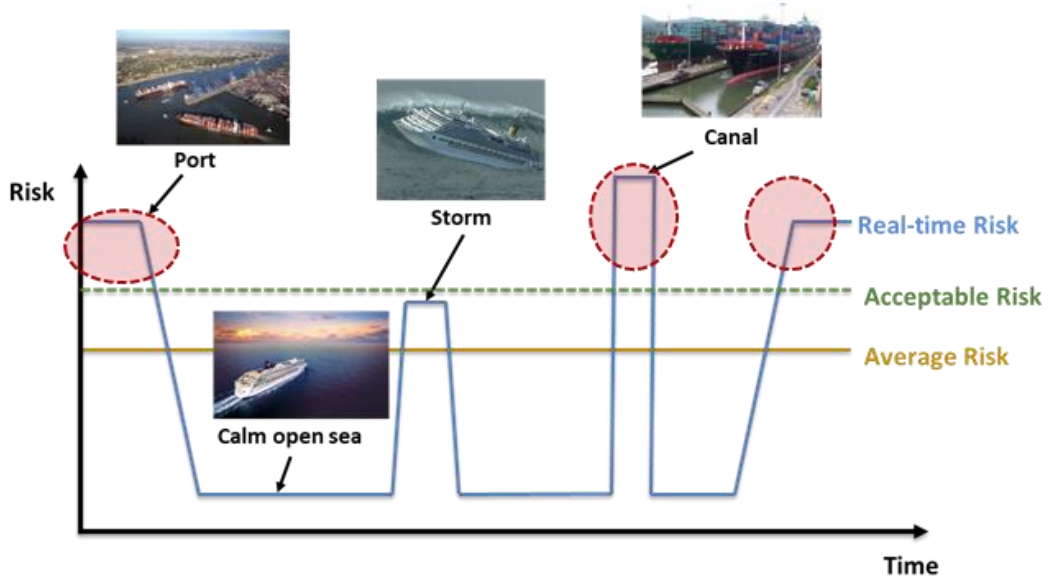

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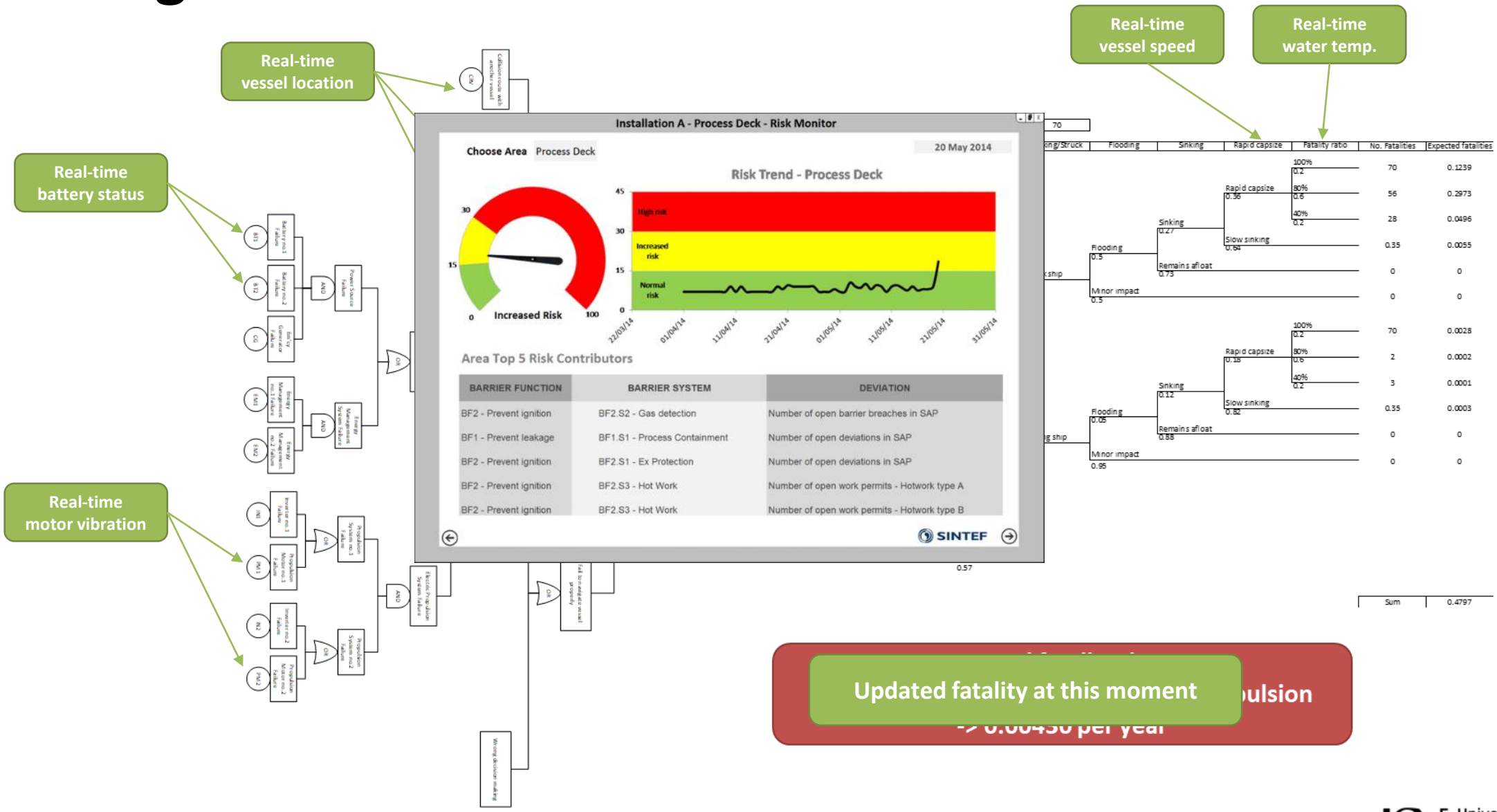

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Real Time Risk Studies







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Summary

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Summary

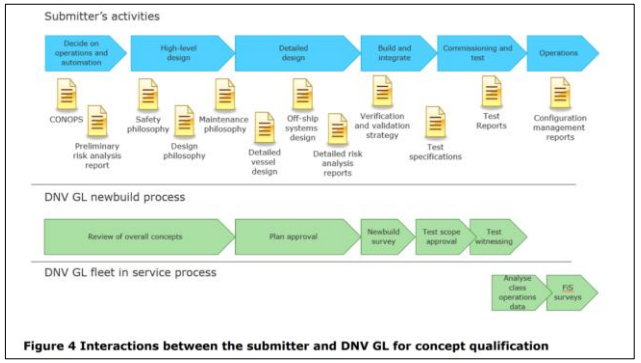
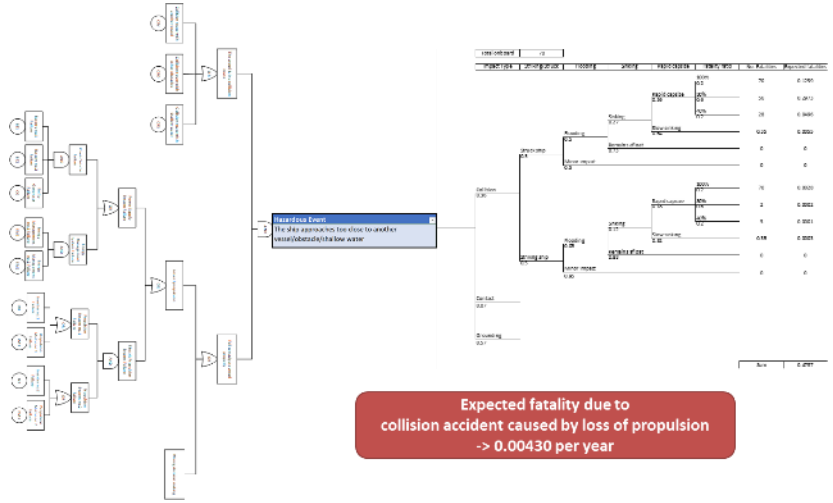


Figure 4 Interactions between the submitter and DNV GL for concept qualification

DNV



		MSC.1/Circ. 1455/2020.	*RSV*
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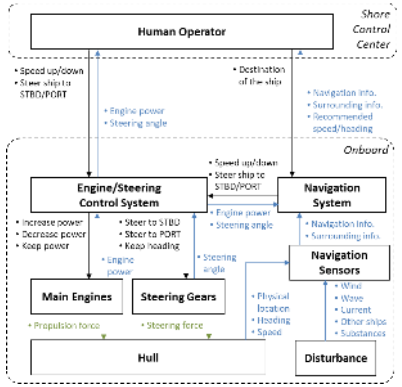
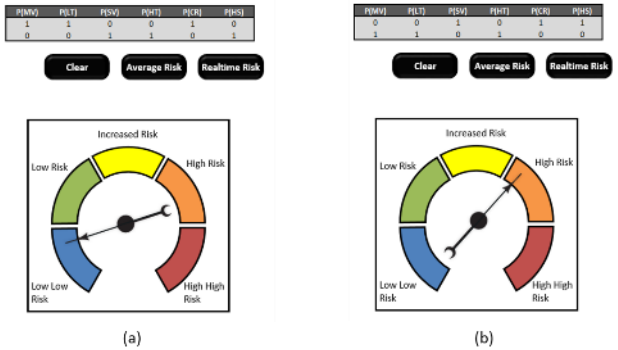
NMA





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