A Formalism for Scalable Maritime Traffic Monitoring for Explainable Anomaly Detection and Resolution at Vessel Traffic Services

Fraunhofer CML

Introduction

A Formalism for Scalable Maritime Traffic Monitoring for Explainable Anomaly Detection and Resolution at Vessel Traffic Services

Introduction

A Formalism for Scalable Maritime Traffic Monitoring
for Explainable Anomaly Detection and Resolution
at Vessel Traffic Services

- Vessel Traffic Service (VTS) centers around the globe monitor maritime traffic
- Their purpose in a nutshell: ensure safety and efficiency of maritime traffic

Introduction

A Formalism for Scalable Maritime Traffic Monitoring
for Explainable Anomaly Detection and Resolution
at Vessel Traffic Services

- The purpose of VTS according to the International Maritime Organization (IMO):
  - “providing timely and relevant information on factors that may influence ship movements and assist onboard decision-making”
  - “monitoring and managing ship traffic to ensure the safety and efficiency of ship movements”
  - “responding to developing unsafe situations”

Introduction

A Formalism for Scalable Maritime Traffic Monitoring
for Explainable Anomaly Detection and Resolution
at Vessel Traffic Services

- To ensure safety and efficiency VTS operators (VTSO) are motivated to apply a decision support tool (DST)

Introduction

A Formalism for Scalable Maritime Traffic Monitoring
for Explainable Anomaly Detection and Resolution
at Vessel Traffic Services

- The purpose of a DST according to the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA):
  - „provide alerts and indicators“
  - „reduce the workload“
  - „enhance efficiency“
  - „be accurate and in real time“

Introduction

A Formalism for Scalable Maritime Traffic Monitoring
for Explainable Anomaly Detection and Resolution
at Vessel Traffic Services

- The processing and output of a system, i.e., an artificial intelligence (AI) can be inherently
  - explainable and interpretable (white box)
  - or not (black box)

Introduction

A Formalism for Scalable Maritime Traffic Monitoring for Explainable Anomaly Detection and Resolution at Vessel Traffic Services

- In safety-critical environments the explainability of a system plays a substantial role:
  - A VTSO must be able to comprehend the processing and output of a DST.
  - The proper functionality of a DST must be verifiable therewith explainable.

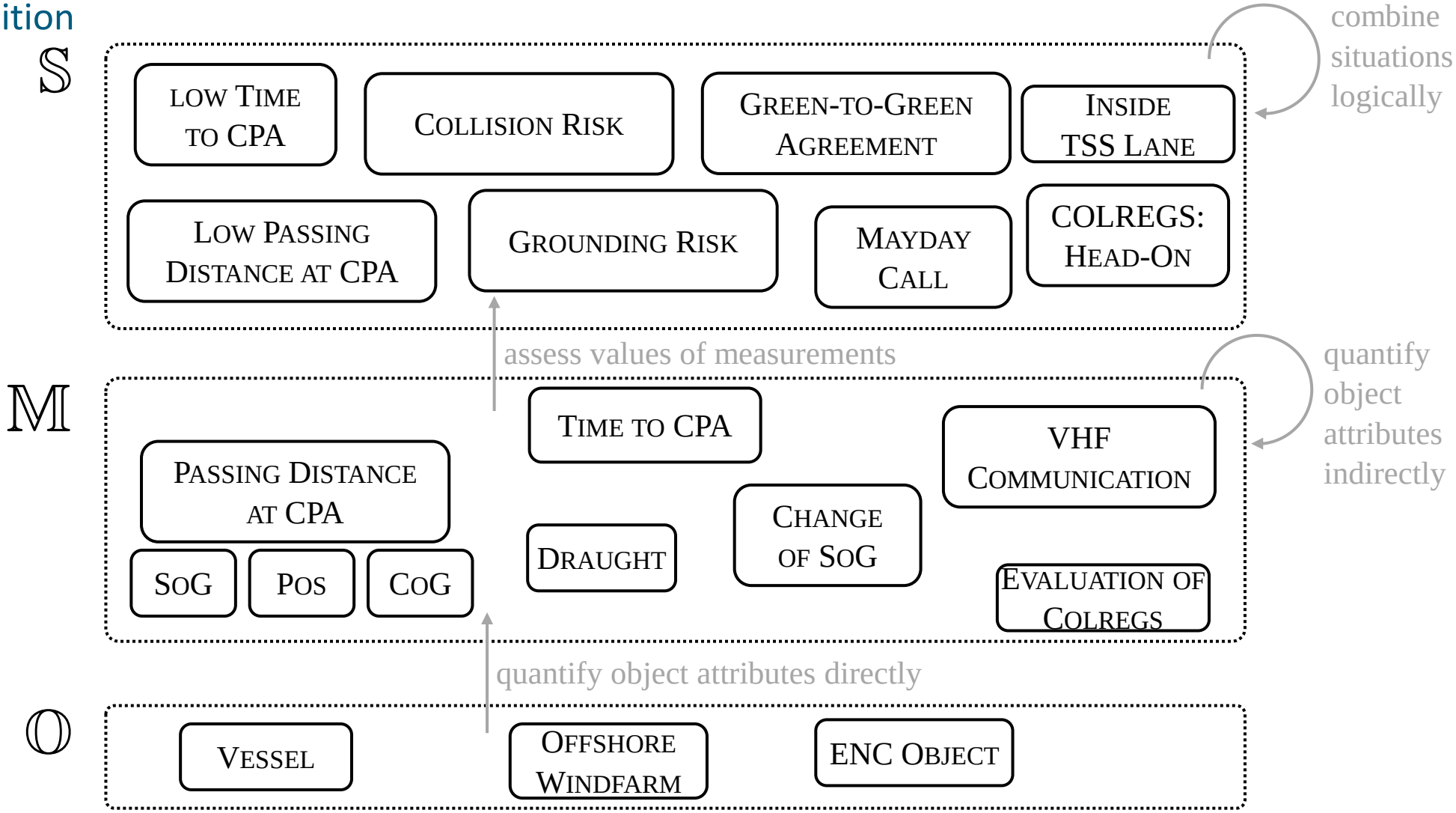
Introduction

A Formalism for Scalable Maritime Traffic Monitoring for Explainable Anomaly Detection and Resolution at Vessel Traffic Services

- VTS centers around the globe monitor and coordinate traffic
  - in various regions
  - where diverse traffic patterns occur
  - using various sensor and communcation technologies

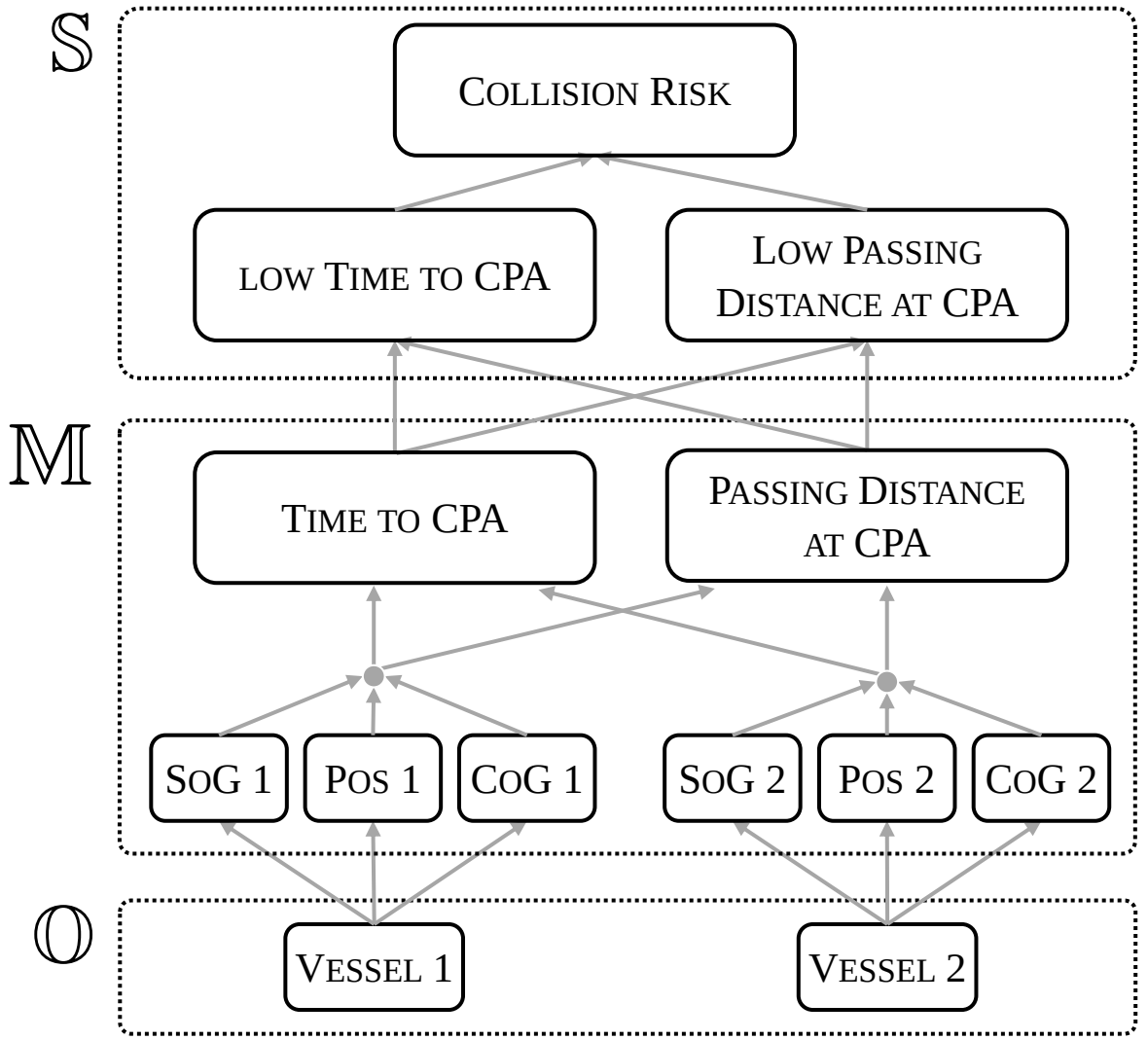
Formalism

Hierarchical definition



Formalism

Example: Detecting Collision Risk



Fraunhofer CML

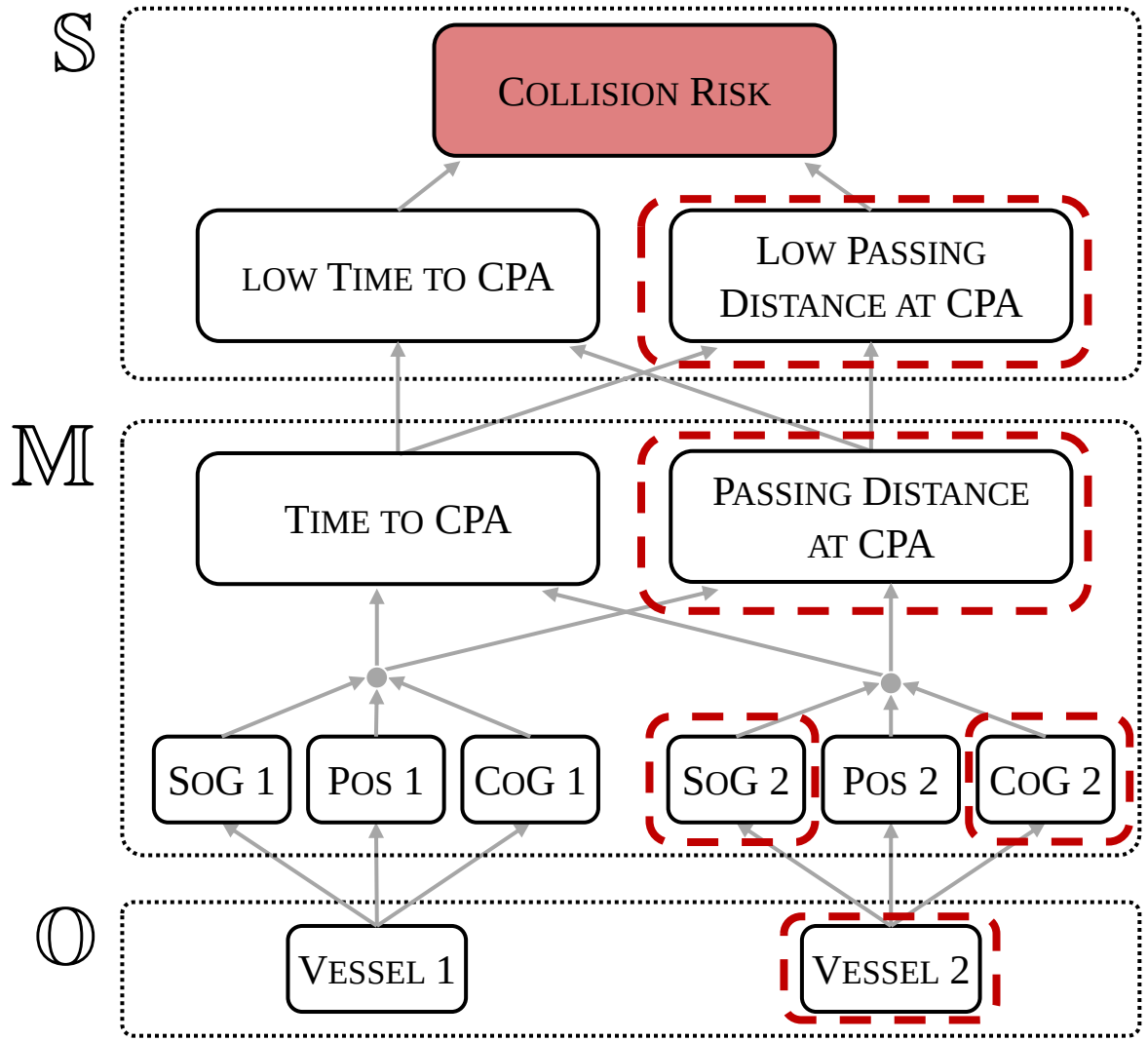
Formalism

Example: Resolving Collision Risk

How to resolve an anomalous situation?

In a nutshell → the reversed process

- track down the composites of the detected anomalous situation
- via a cost function calculate which manouver is the „best“ to avoid the anomalous situation



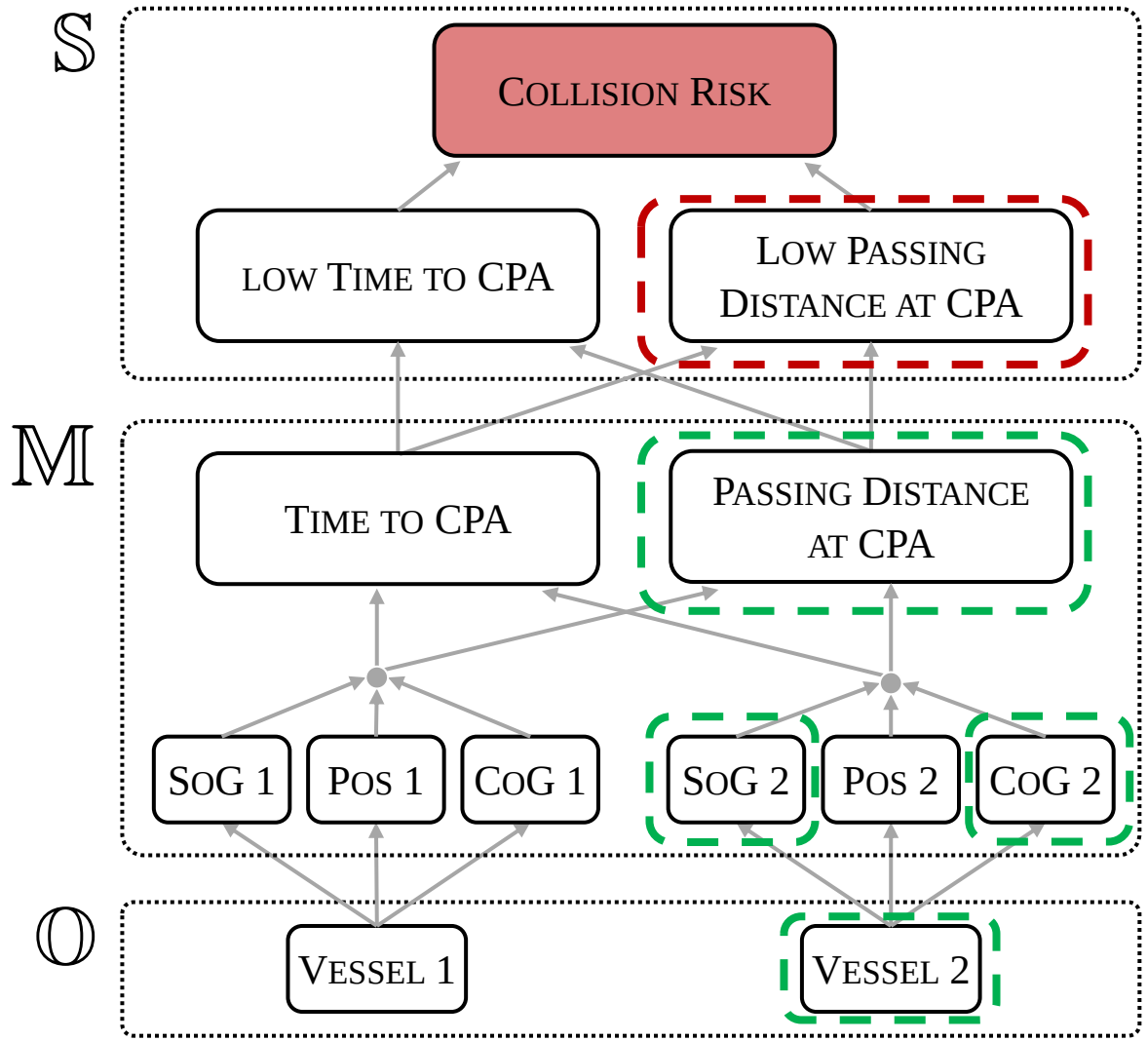
Fraunhofer CML

Formalism

Example: Resolving Collision Risk

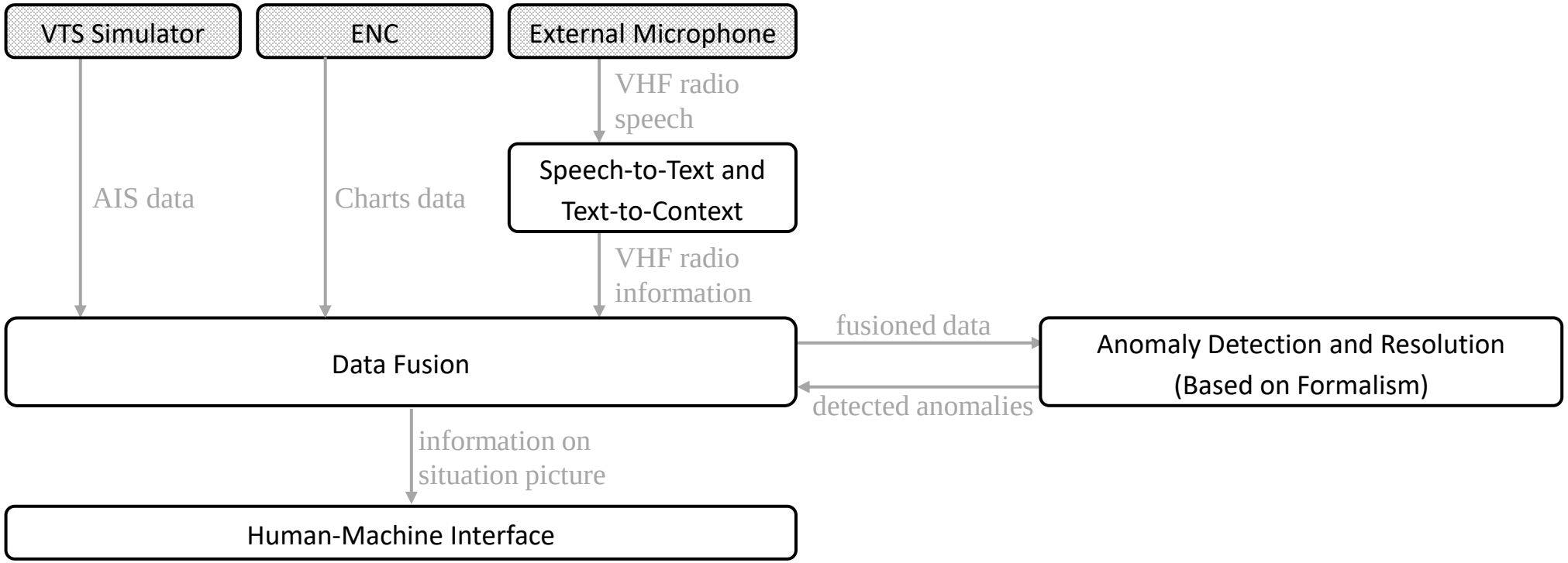
in a nutshell → a reversed process

- track down the composites of the detected anomalous situation
- via a cost function calculate which change is the „best“ to avoid the anomalous situation
- return recommended resolution for anomalous situation



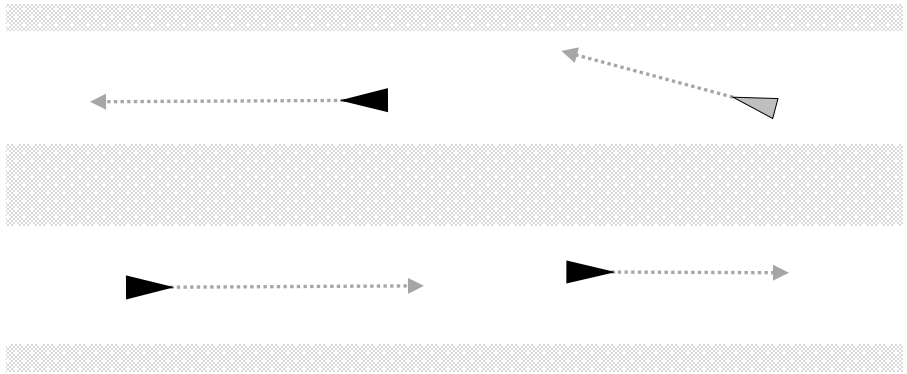
Proof of Concept

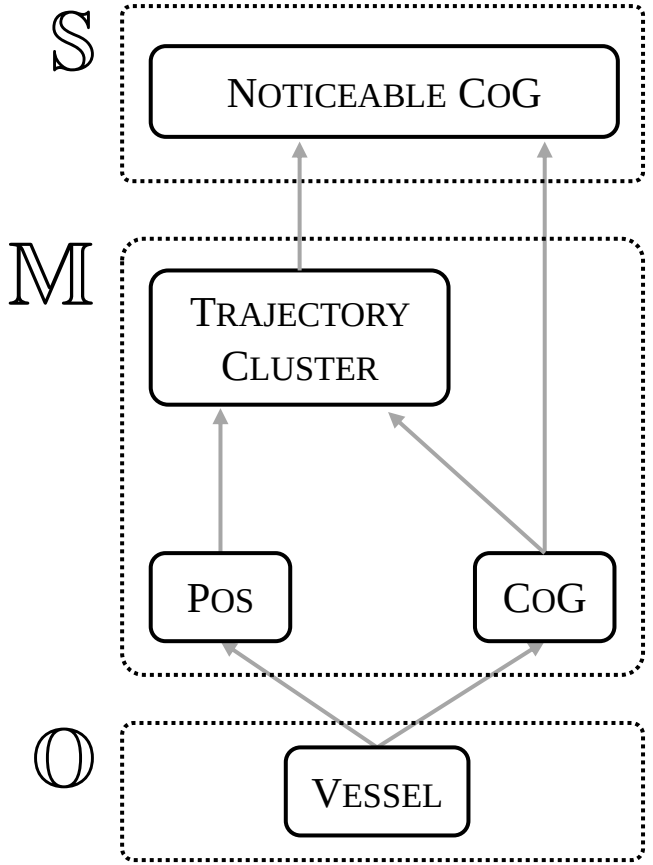
System Architecture of Demonstrator



Proof of Concept

Anomaly Example 1: Noticeable Course over Ground

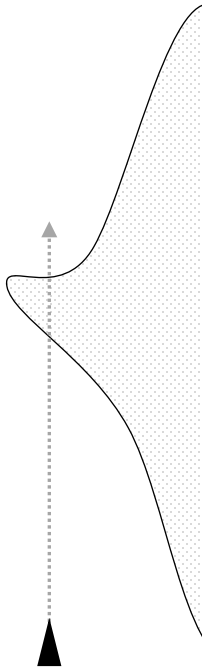


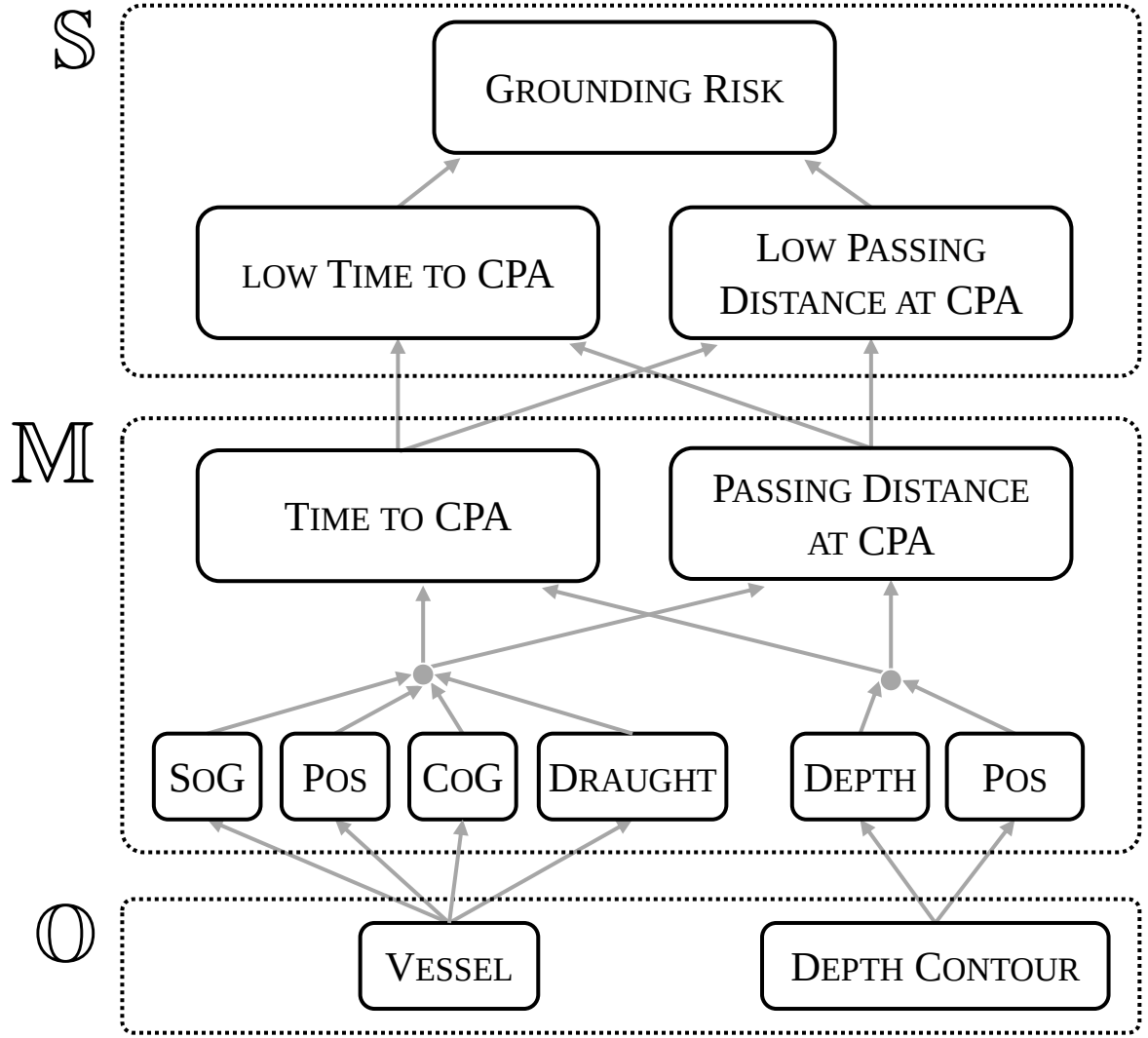


Fraunhofer CML

Proof of Concept

Anomaly Example 2: Grounding Risk

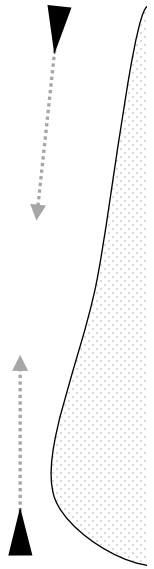


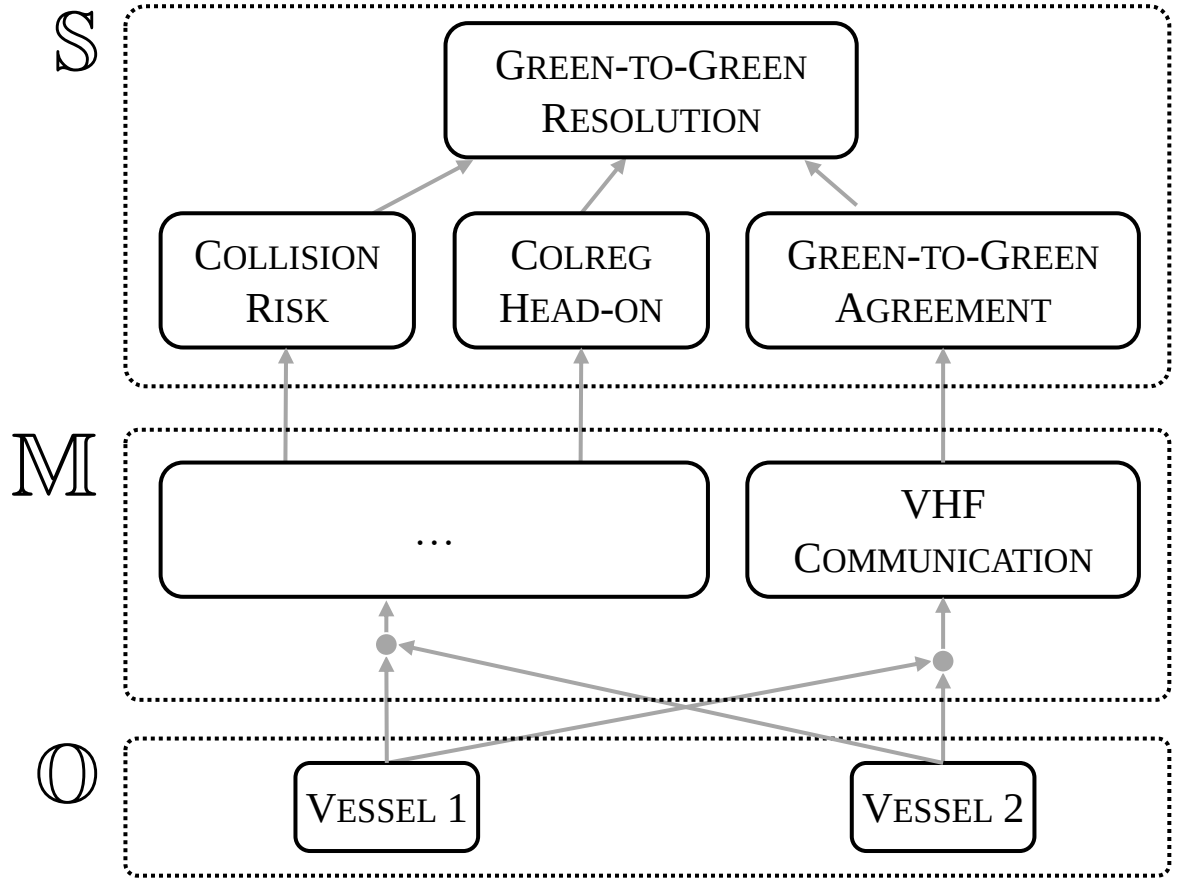


Fraunhofer CML

Proof of Concept

Anomaly Example 3: Green-to-Green Resolution





Fraunhofer CML

Conclusion

We proposed „A Formalism for Scalable Maritime Traffic Monitoring for Explainable Anomaly Detection and Resolution at Vessel Traffic Services” that

- **combines information** from various data **sources** for a holistic traffic situation awareness
- provides information in a **reasonable and explainable** manner
- is **adaptable** to various technological equipment at VTS centers and spatio-temporally depending traffic patterns

We demonstrated its feasibility with a few examples and application as a demonstrator in the project *LEAS* (grant number 13N16246 managed by VDI Technologiezentrum).

Thank you for your attention!

M. Sc. Thomas Stach

thomas.stach@cml.fraunhofer.de
+49 (0) 40 / 794 1681 - 1513

Fraunhofer CML

Fraunhofer-Center für Maritime Logistik und Dienstleistungen CML