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Key Safety Indicators using STPA

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Table of contents

Background

- This paper is based on the author's PhD research
- Original PhD hypothesis: Ship operators with better risk management should have better safety
  - Could not be proven due to low maturity of risk management observed
- Companies were focused on developing and implementing a safety management system (SMS) compliant with the International Maritime Organization (IMO) standards
  - International Safety Management (ISM) Code requires ship operators to “assess all identified risks to its ships, personnel and the environment and establish appropriate safeguards
- Research evolved to create key safety indicators to track the performance of the SMS that allow ship operators to track and improve their safety performance

Motivation

- IMO data on very serious accidents shows a high number of ship accidents and losses each year
  - Although data has a positive trend for the past few years, number of serious accidents remains >100
- Literature review identified that current safety indicators were developed based on recommendations from panels of subject matter experts based on past experience
- Use a more structured systems approach (STPA) to generate a set of safety indicators to allow ship operators the ability to track their SMS performance

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IMO Global Integrated Shipping Information System Data

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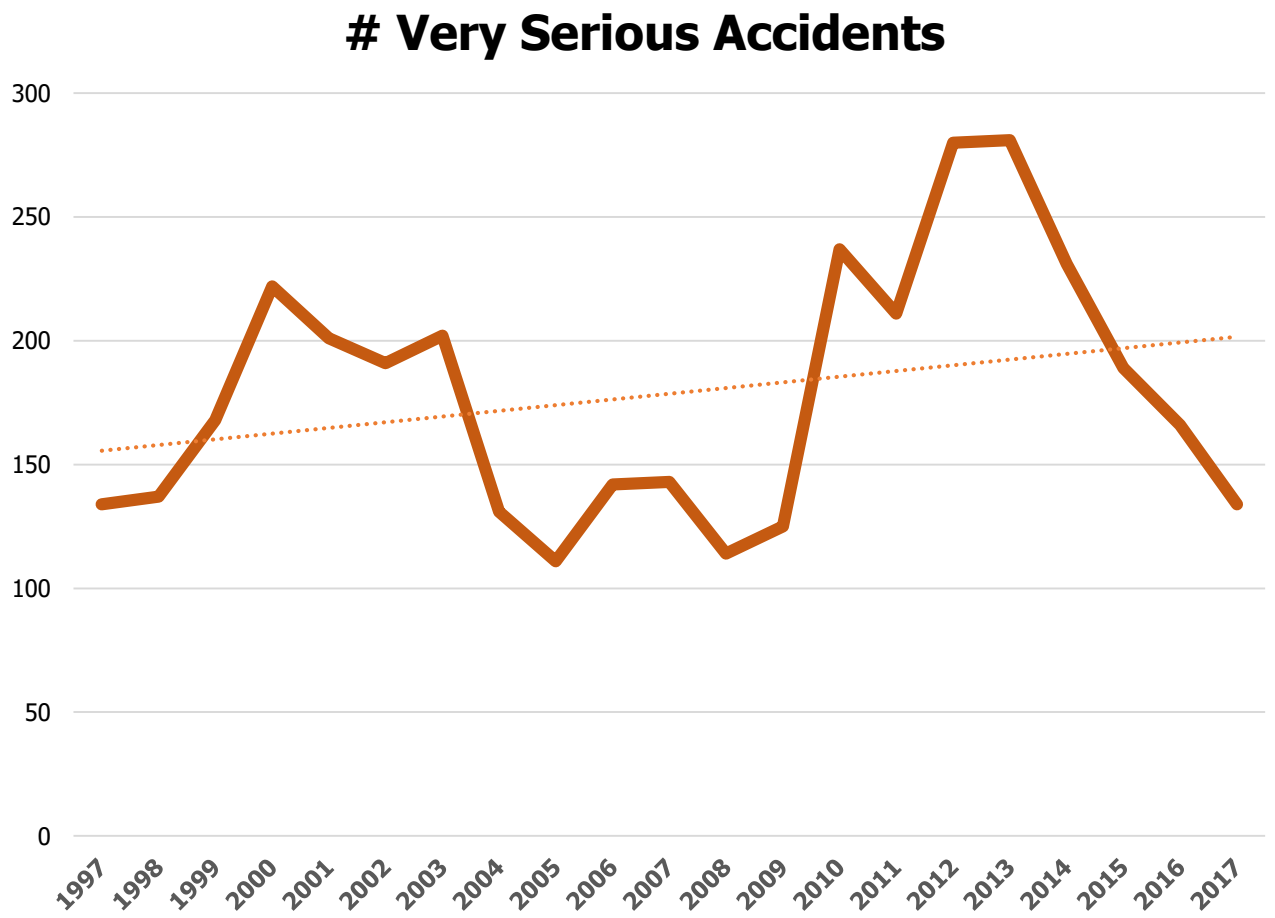


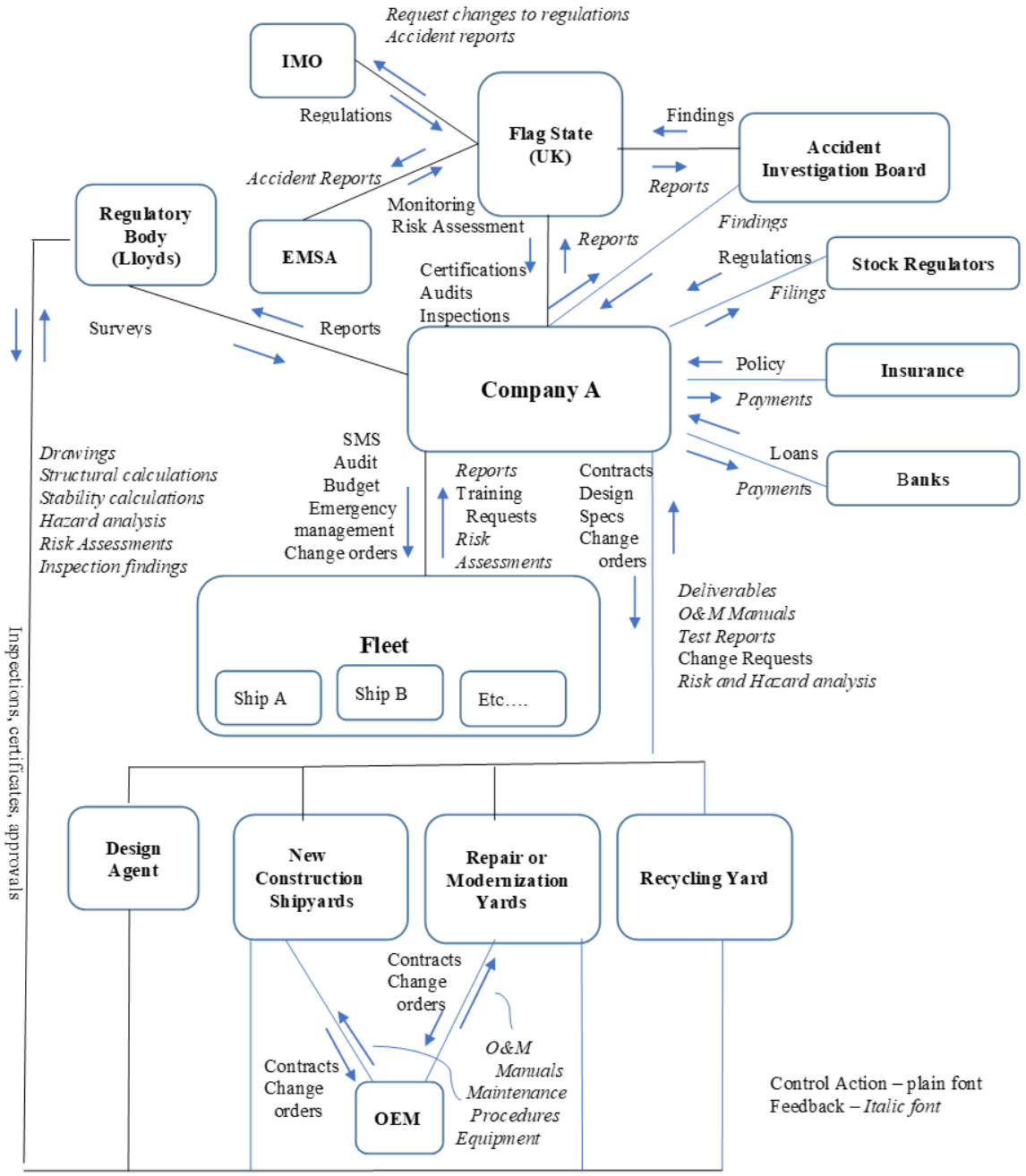
Aims and Objectives

- Overall aim of this research was to develop a set of key safety indicators
- High-level objective was to improve the safety feedback process within cruise and ferry management operations
- Low-level objectives were to develop a repeatable methodology available to all ship operators for improving safety management by:
  - Outlining the methodology
  - Modelling the SMS at two companies to assess the approach
  - Using systems theory to perform systematic hazard analysis of entire safety control structure
  - Developing, classifying and ranking safety indicators
  - Creating an initial set of generic safety indicators

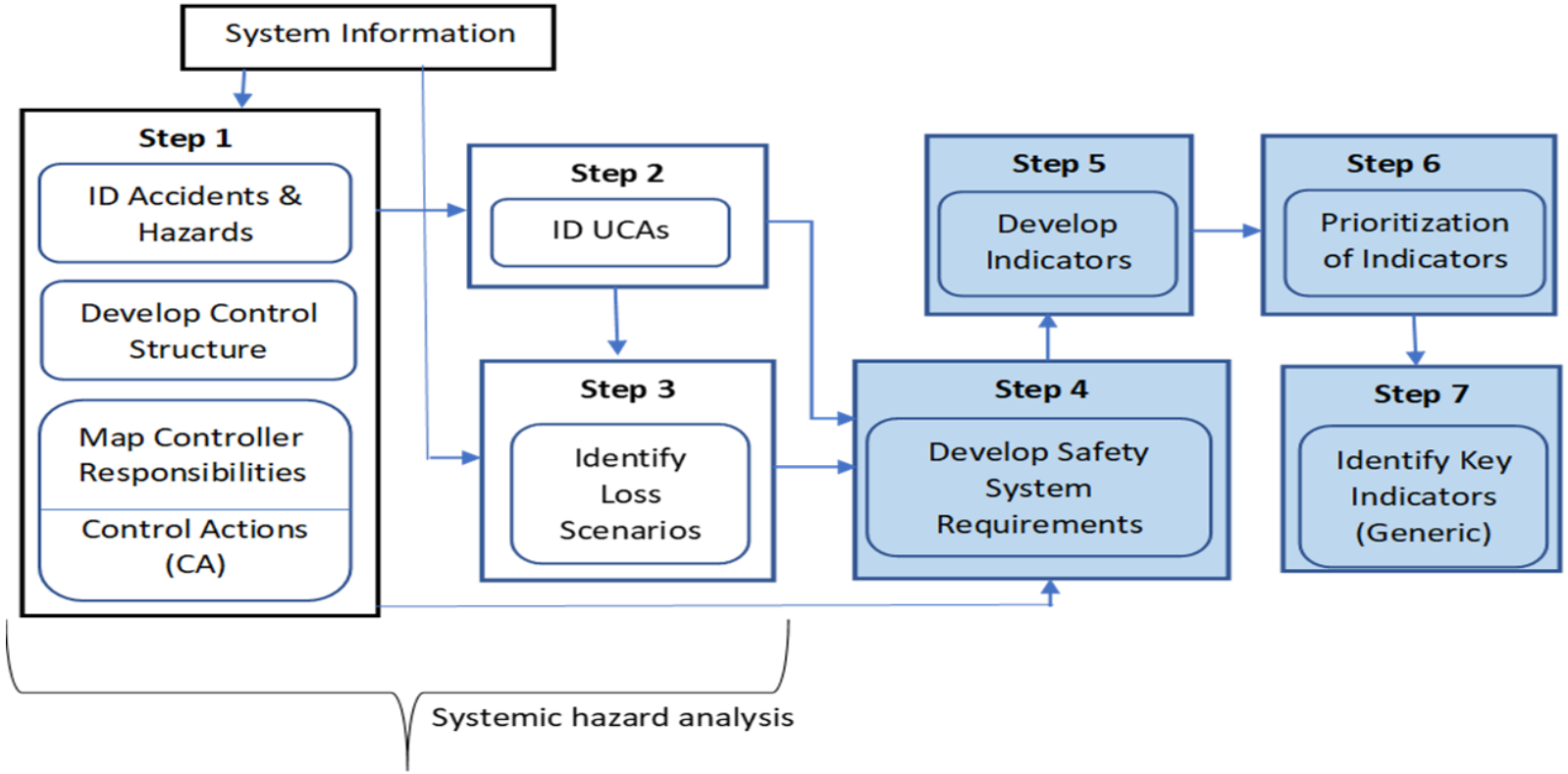
Methodology

- Hazard and risk models reviewed
- Method selected to model each ship operator's SMS is based on systems theory. This approach captures the complex, multi-level control structure representative of today's ship management approach
- Leveson's System Theoretic Process Analysis (STPA) applies a structured hazard analysis to find where a control/management structure is inadequate
- Uses a top-down process to build a hierarchical model of the safety management system

Company A control structure



STPA Process



STPA extension

Steps 1-3 form the core of the STPA hazard analysis

- SMS hazards identified by following control actions by each controller
- Hazards categorized by type
  - SMS is not designed according to standards
  - SMS is not implemented in accordance with company policy
  - SMS and risk management are not well integrated
  - SMS and risk management are not well suited for the organization
  - SMS and risk management are not effective
- Control Actions traced to hazards, then Unsafe Control Actions identified, and loss scenarios generated.

Step 4-7 are the extensions done for this research to create indicators of SMS performance

- Safety system requirements for each loss scenario were created, then an indicator was generated to track that the requirements were being met. Final steps were to prioritize the indicators then create generic indicators from indicators common to both companies.

STPA example

Control Action (CA) – Safety alert

- Safety Committee onboard receives and responds to a safety alert

Unsafe Control Action (UCA)

- Safety alert issued, but lacks specificity to work on every ship in the fleet

Loss scenario

- Broad or general safety alert does not “fit” every ship, allowing a potential accident, incident or near miss to occur

Safety system requirement

- Safety alerts shall be focused and specific for each ship so they can be effective

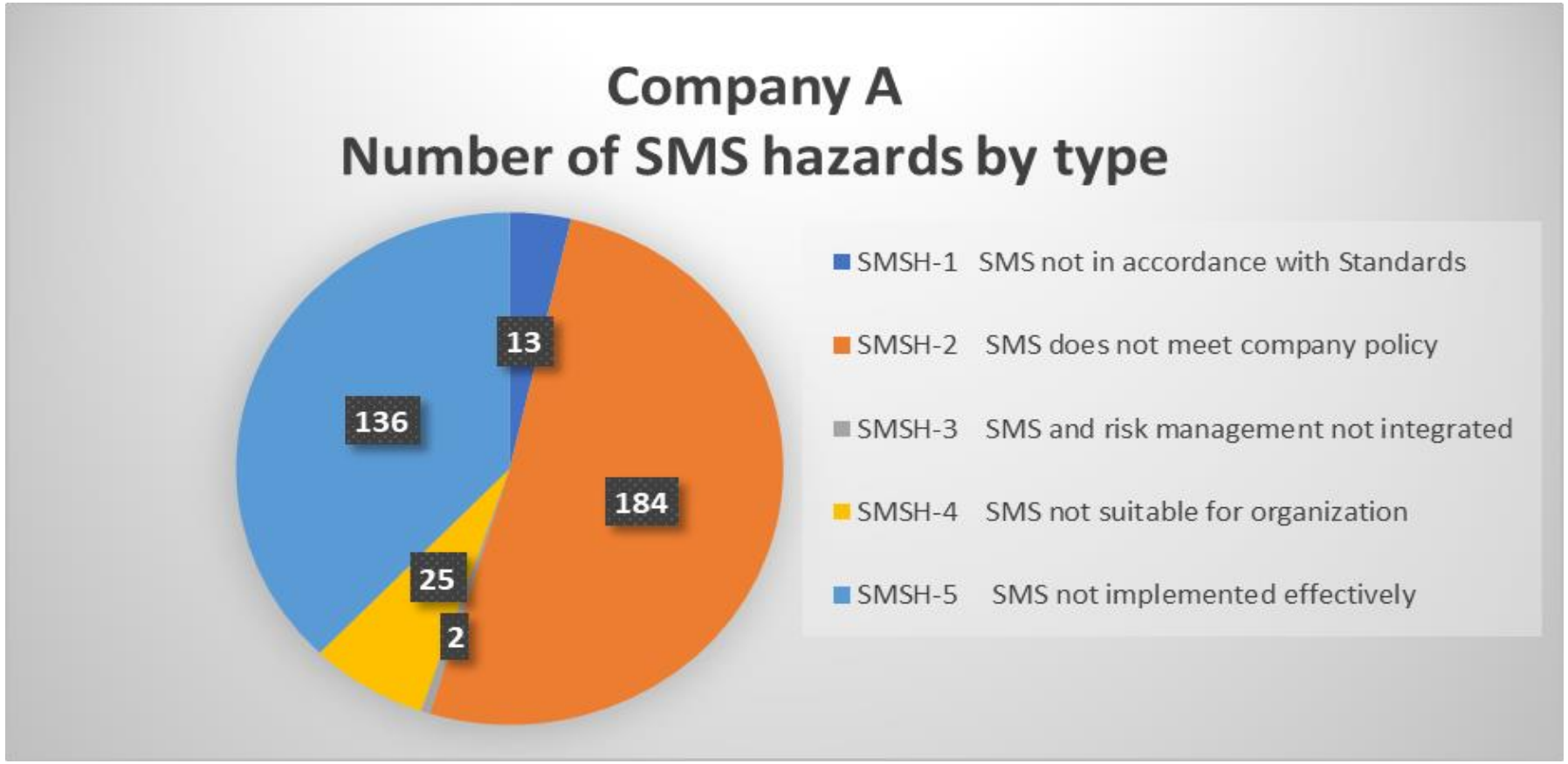
Safety system indicator

- Quality of safety alert shall be assessed annually

Results

- SMS hazards identified by following control actions accomplished by each controller
- Hazards categorized by type
  - SMS is not designed according to standards
  - SMS is not implemented in accordance with company policy
  - SMS and risk management are not well integrated
  - SMS and risk management are not well suited for the organization
  - SMS and risk management are not effective

Results


Company A
Number of SMS hazards by type
13
184
25
2
136
SMSH-1 SMS not in accordance with Standards
SMSH-2 SMS does not meet company policy
SMSH-3 SMS and risk management not integrated
SMSH-4 SMS not suitable for organization
SMSH-5 SMS not implemented effectively

Results

Function	# Company A	# Company B
Controllers	26	35
Control Actions (CAs)	105	100
Unsafe Control Actions (UCAs)	364	310
Loss scenarios (LSs)	364	310
Safety System Requirements (SSRs)	364	310
Safety System Indicators (SSIs)	278	270
Priority level 1 SSIs	53	69

Results

- Safety system indicators in the following categories were created:
  - Safety Policy & Objective Indicators (SPOIs)
  - Safety Assurance Indicators (SAIs)
  - Safety Risk Indicators (SRIs)
  - Safety Promotion Indicators (SPIs)
- Prioritization of indicators was accomplished by working with each controller. Highest Priority (Pri1) became Key Indicators.
- Example – for Company A there were 53 Priority 1 system indicators, 163 Priority 2 and 62 Priority 3 indicators for a total of 278 indicators
- Prioritization allows a focus on the more critical indicators. Following Pareto's 80-20 Rule and David Parmenter's 10-80-10 Rule the author proposes a more refined break-out by the above categories, for Stu's (4x5)x80 Rule.

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Company A Indicators

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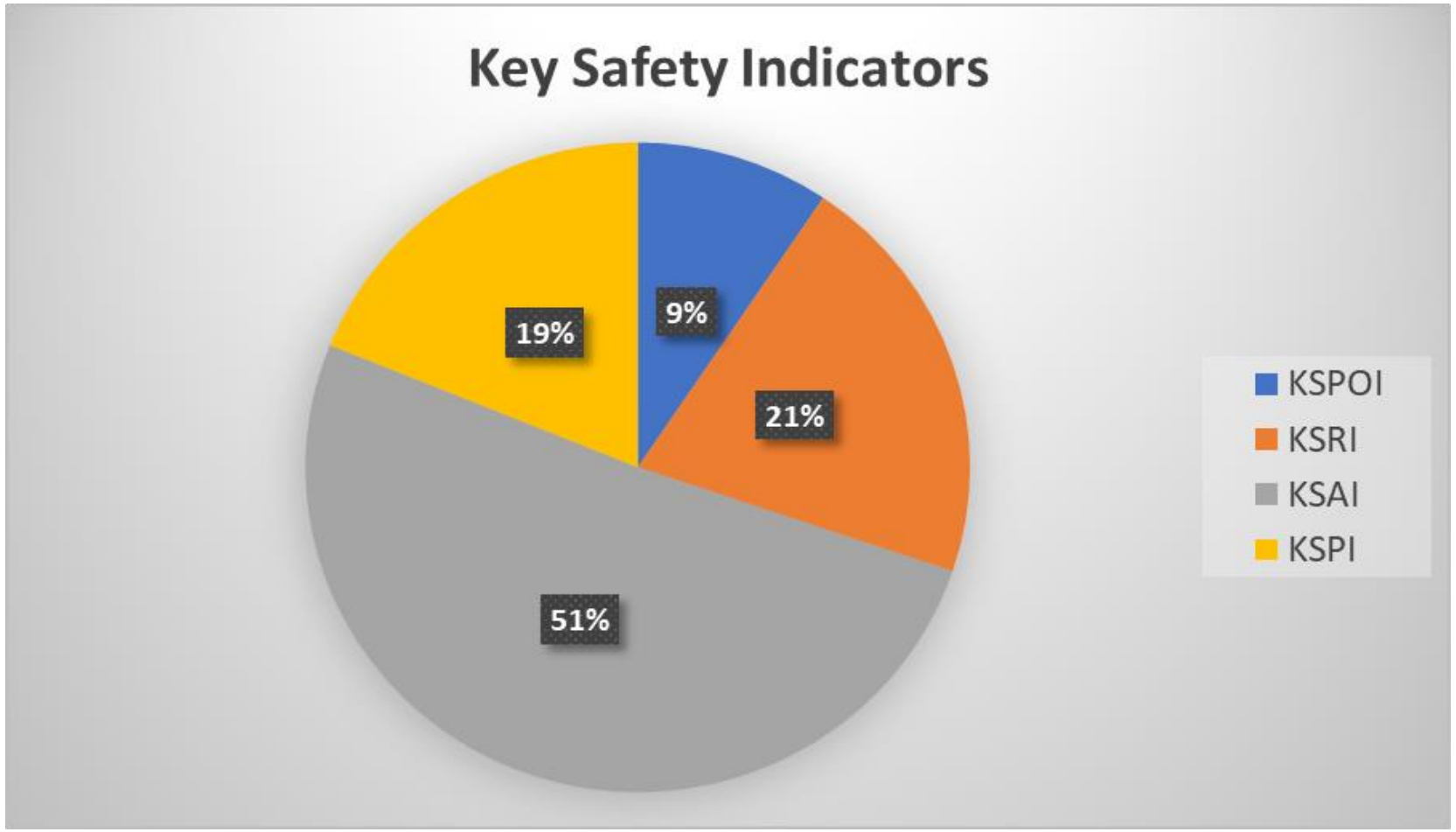

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Company A
Key Indicators

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Indicator Type	System Indicator Name	Description
Assurance	Audit	Number of new findings each review cycle shall be tracked and reviewed annually.
Assurance	Audit	Number of repeat findings each review cycle shall be tracked and reviewed annually.
Assurance	Environmental report	Number of environmental deficiencies open and unresolved reported weekly.
Assurance	Planned maintenance	Number of planned maintenance activities scheduled, but not completed, reported monthly.
Policy & Objectives	Risk Appetite	Time between updates to the Risk Appetite document shall be tracked and reported annually.
Promotion	LSA drill	Percentage of lifesaving appliance drills accomplished on schedule fleet wide.
Promotion	Training request	Number of training requests not approved, reported monthly.
Risk	Accident/Incident/Near miss reports	Number of accident/incident/near miss reports that are open, with no conclusion as to root cause identified summarized and tracked on a monthly basis.
Risk	Resources	Risk mitigation funding shall be tracked and reported on monthly.

Summary

- The objective of developing safety indicators using STPA to track the performance of SMSs was achieved.
- Very positive response at both companies
  - Company A revising their set of safety indicators and reviewing their procedures for closing out audit findings
  - Company B revising their risk management approach, including driving the risk process down to each ship in their fleet.
- IMO responded positively to the need for revisions to the ISM Code
  - They want results presented at a future Maritime Safety Committee (MSC) meeting