

MARITIME

# Goal-Based Standards & SLA

Idea and situation

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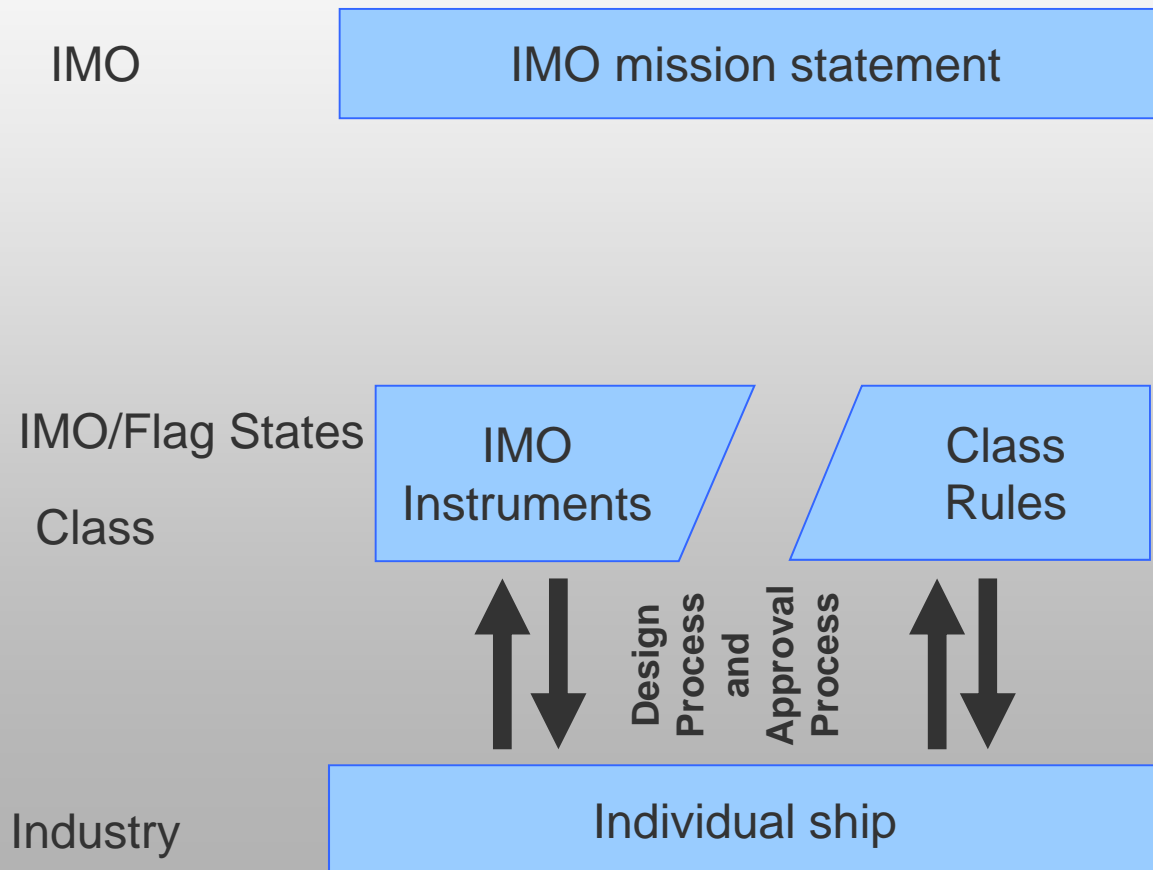
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## Current regulatory framework (SOLAS – MARPOL – Rules)



# Motivation<sub>1</sub>

- Shipping industries have continuously introduced technological innovations and will continue
- Technological innovation use latest technologies
- Regulatory framework mostly empirical based and prescriptive
- Prescriptive regulations and rules can only consider past “state-of-the art”
- Consequence: regulatory framework hampering innovation by limiting design space (unable to cope with diversity of design solutions)



**Regulators realise shortcomings of prescriptive regulations!**

# Motivation<sub>2</sub>

- First reaction: Open some regulations for alternatives



**ALTERNATIVE DESIGN (Reg.17 Chapter II-2: adopted December 2000)**

- Additionally: a discussion asking for “building robust ships”<sup>1</sup>, was initiated in context of the Bulk Carrier Safety discussion (2002)
- At MSC 73 (2003) the term Goal Based Standards<sup>2</sup> was firstly used at IMO

<sup>1</sup>Greece MSC 76/5/10, 2002

<sup>2</sup>Bahamas & Greece, MSC 77/2/5

# Goal Based Standards

# Why Goal Based Standards (idea behind)?

Goal-Based Standards discussion was introduced at IMO with the aim to

- refrain from having detailed prescriptive provisions for every aspect
- should state what has to be achieved, rather than precisely how it should be achieved
- open for different approaches and innovation



# First Phase of GBS discussion at IMO<sub>1</sub>

- Until MSC 82 (2006) two deviating positions were developed:

## deterministic

- Apply deterministic methods for developing regulations and rules
- Compliance: review by group of experts



## risk-based

- Apply risk-based methods for developing regulations and rules
- Compliance: apply risk-based methods for verification

- Until MSC 87 discussion considered too many and various aspects in parallel



small progress



# GBS: deterministic vs. safety level

## Deterministic

Specify a set of requirements for all influences

- Specified design life shall not be less than 25 years
- *Net scantlings required to meet structural strength provisions are maintained throughout the specified design life*
- Deterministic determination of net scantlings

## Safety level

Specify safety requirements in quantitative terms (risk level)

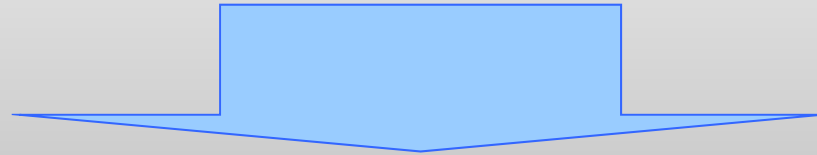
- Depends on case, a useful ship life in the order of 25 years may be anticipated
- IMO would define a minimum safety level for all ships regardless of age
- Risk-based determination of safety level

# First Phase of GBS discussion at IMO<sub>2</sub>

- At beginning GBS discussion was focused on ship structure

## **“GOAL-BASED NEW SHIP CONSTRUCTION STANDARDS”**

- Meanwhile more and more Flag States see a need to consider
  - all IMO regulations (SOLAS, MARPOL, STCW)
  - not only systems but also human factor/performance



Discussion on GBS was continued after finalisation of

## **“International goal-based ship construction standards for bulk carriers and oil tankers”**

MSC 88 agreed that this work should continue, acknowledging that this would be a longer term project ... [considering] the expansion of the scope beyond structural requirements.

# What is GBS safety level approach?

- **GBS idea:**  
Define goals and requirements for demonstrating compliance with these goals
- **Advantages:**
  - Goals are focused on safety and therefore independent from technological development
  - Appropriate compliance demonstration opens space for innovation
- **Safety Level Approach:** apply risk-based methods to
  - Justify regulations and rules
  - Monitor and adjust current safety level (IMO: FSA)

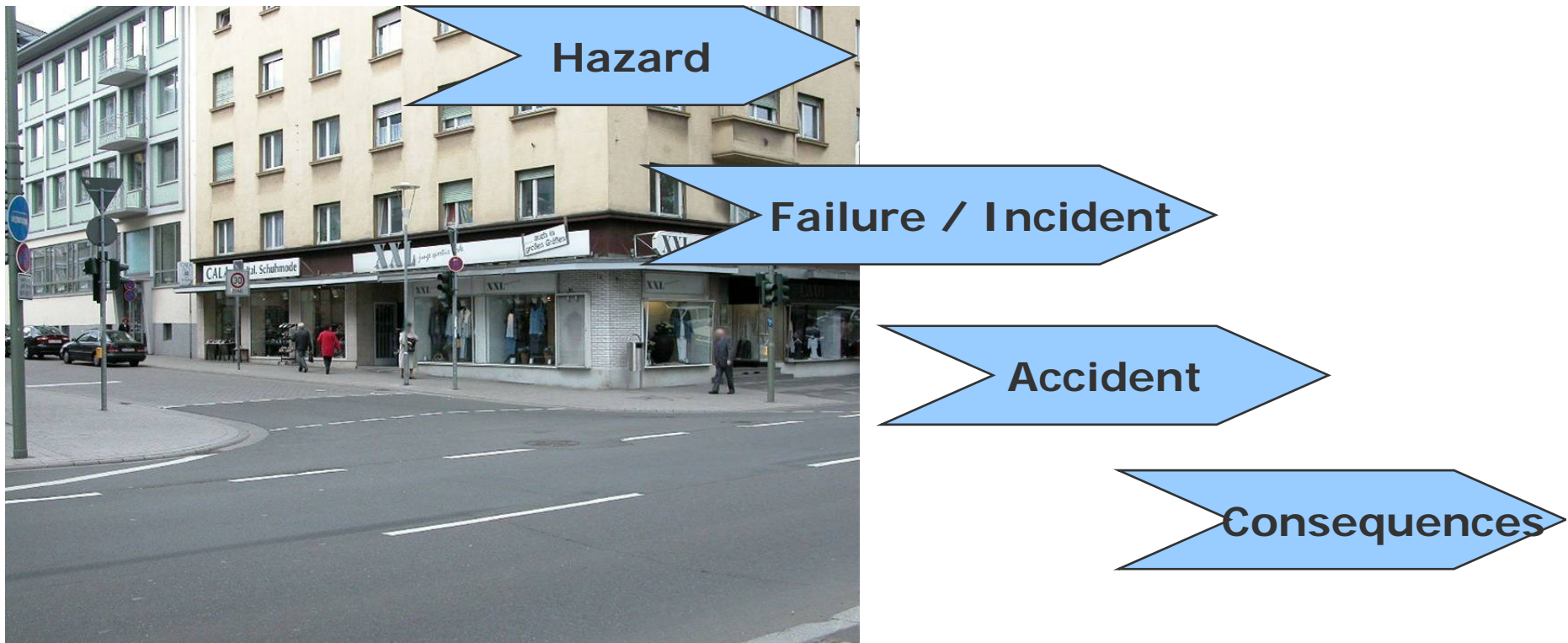
**Safety ~ Risk**

**Safety is absence of unacceptable levels of risk to life, limb and health (from unwillful acts) (Source: IACS FSA Glossary, GBS Guidelines)**

**FSA: Formal Safety Assessment**

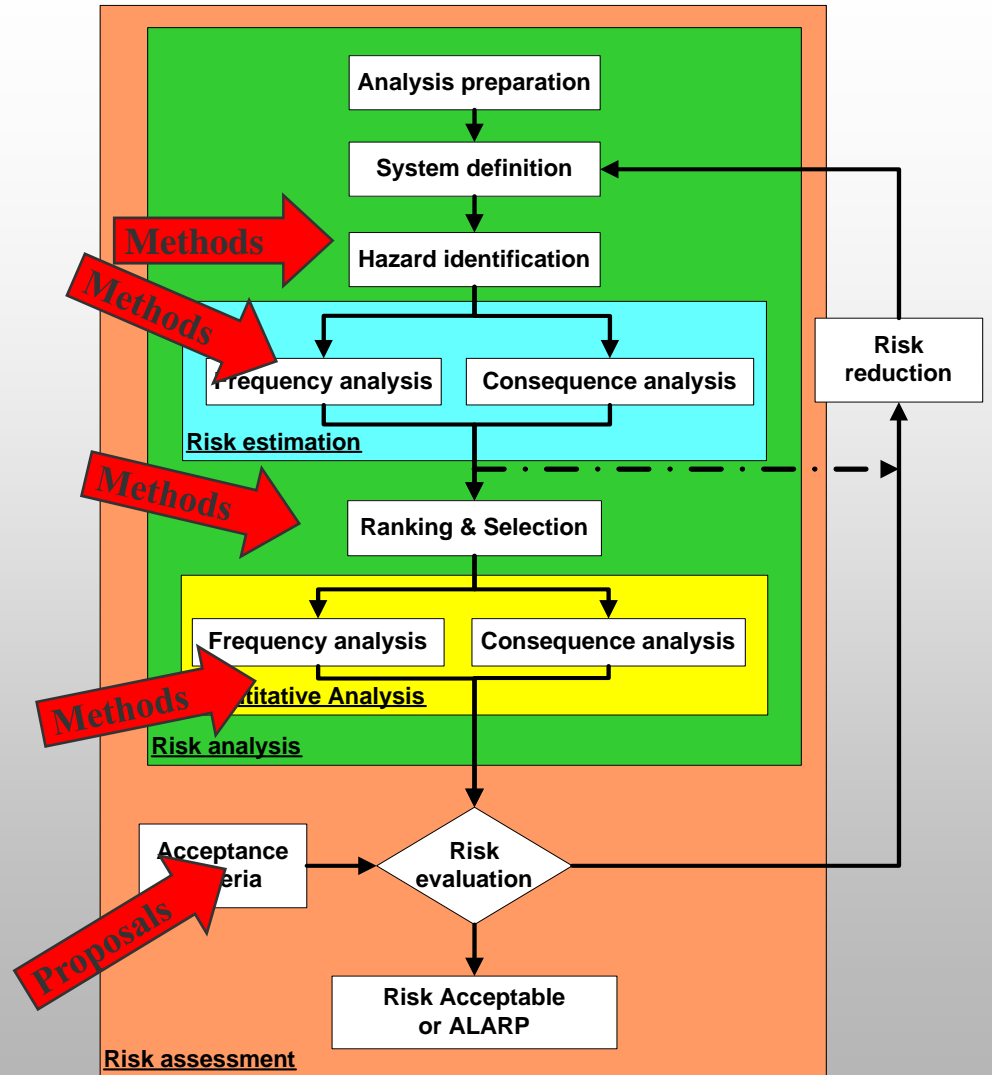
# Risk analysis/risk-based regulations

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# Risk Analysis

- Risk Analysis is a structured process consisting of
  - determination of main risk contributors
  - development of a quantitative risk model
  - risk evaluation
  - risk reduction
- Variety of methods available to perform single task
- For risk evaluation:  
*Communication of risk*  
Examples:
  - individual risk, societal risk
  - spilled oil
- *Risk assessment:*  $R_{\text{Design}} \leq R_{\text{acceptable}}$



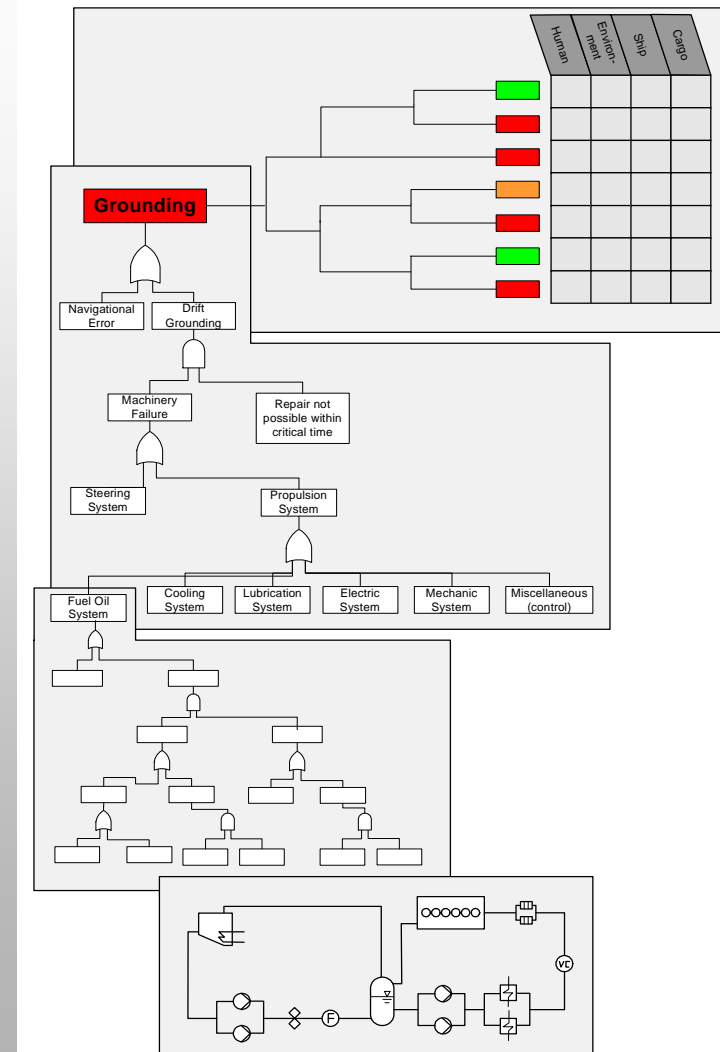
# Risk-Based Regulations

- If current regulations are applied, the design is considered safe. But the level of risk involved is not explicitly known.
- For risk-based regulations/rules, the following additional equation enters in regulation development process:

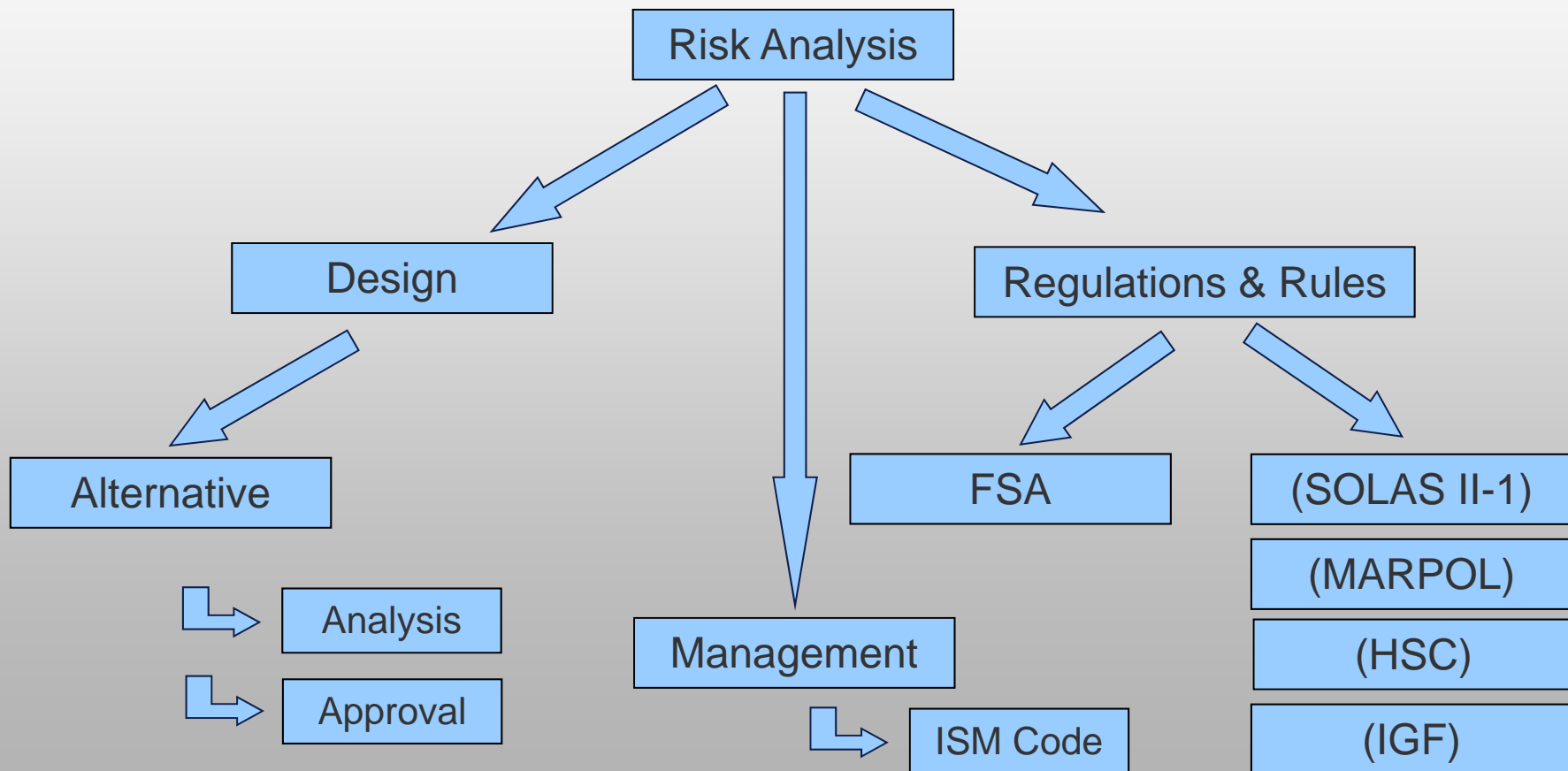
$$R_{Regulation} \leq R_{acceptable}$$

- $R_{Regulation}$  is the expected loss, and it is determined with a risk analysis.
- For risk-based regulations:  $R_{acceptable}$  is defined by IMO

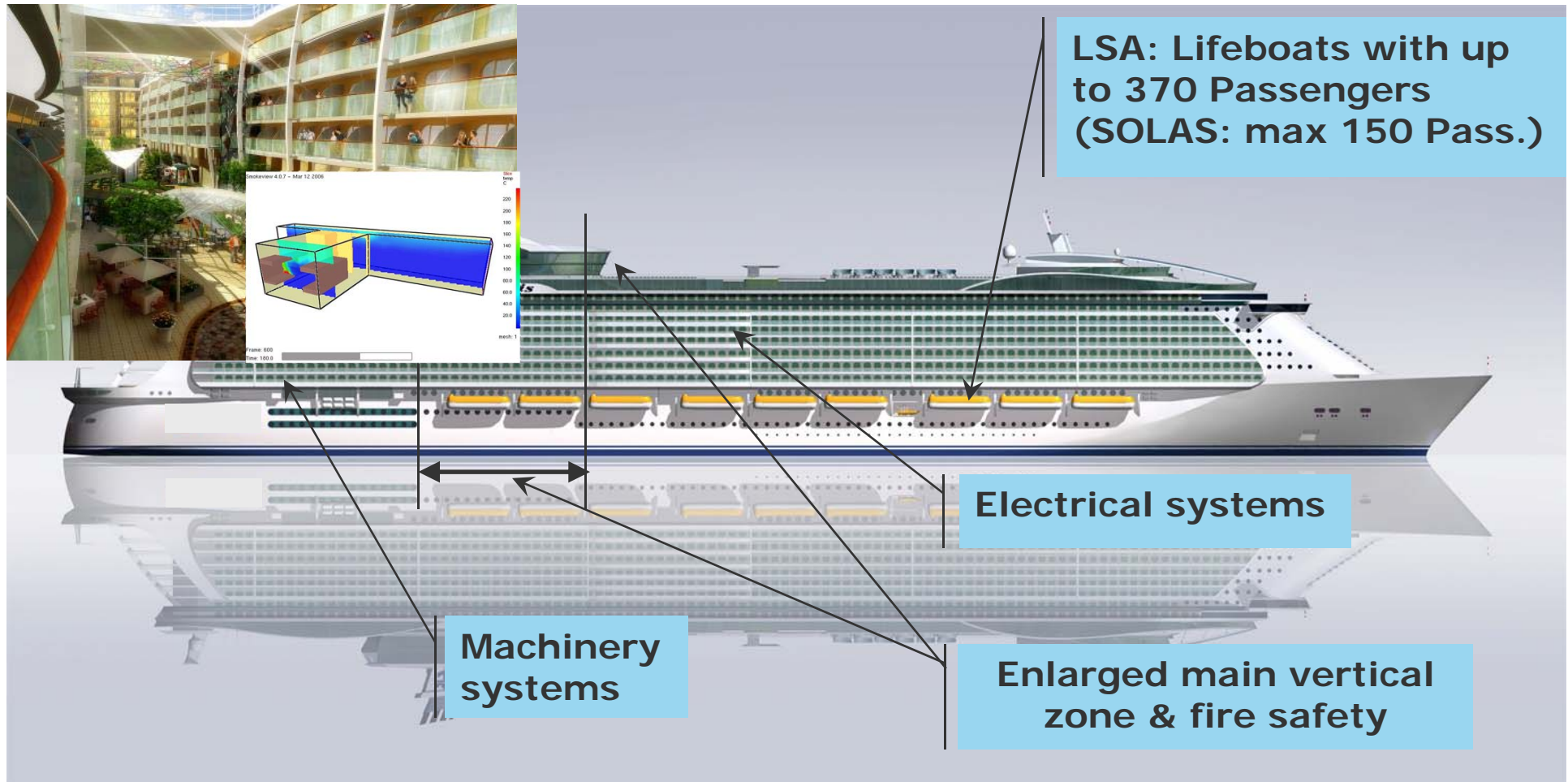
**Is "risk" basically new in IMO regulatory framework?**



# Application of Risk-Based Approaches

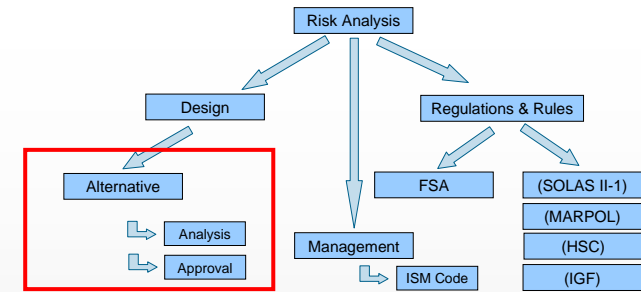


# Design: Alternative Design Application





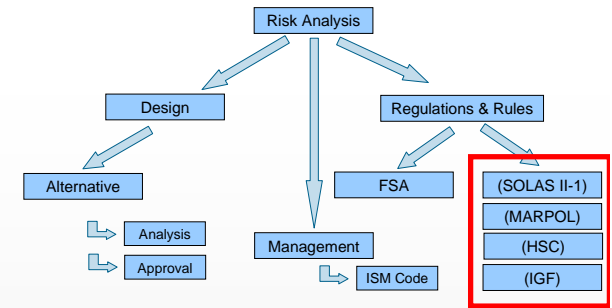
## Design: Alternative Design (SOLAS)<sub>2</sub>



- In order to demonstrate safety equivalence a risk analysis is required
- Challenges:
  - safety level of regulations not explicitly given
- Alternative design requires an approval process because it differs significantly from the traditional design w.r.t.
  - Methods applied
  - Complexity of analysis
  - Results
- Alternative design requirements summarised in MSC/Circ. 1002 and MSC/Circ. 1212
- New guidelines recently agreed by IMO (MSC.1/Circ.1455):  
**THE APPROVAL OF ALTERNATIVES AND EQUIVALENTS AS PROVIDED FOR IN VARIOUS IMO INSTRUMENTS**

Considers also  
SOLAS CH 1 Part A Reg.5

# Regulations & Rules: SOLAS II-1 B



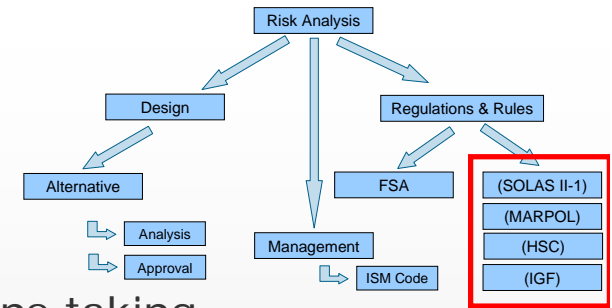
- SOLAS already contains some “GBS” regulations!
- Damage stability requirements in Parts B-1 through B-4 shall apply to cargo ships of 80 m in length (L) and upwards and to all passenger ships regardless of length but shall exclude those cargo ships: example passenger ship

$$A \geq R = 1 - \frac{5,000}{L_s + 2.5 \cdot N + 15,225}$$

$$A = \sum_i p_i \cdot s_i$$

- $p_i$ : accounts for the **probability** that only the compartment or group of compartments under consideration may be flooded ...
- $s_i$ : accounts for the **probability** of survival after flooding the compartment or group of compartments ...

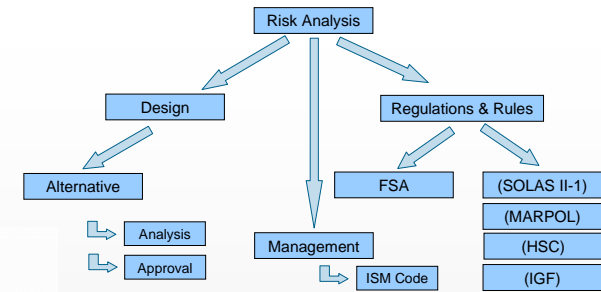
# Regulations & Rules: New Codes



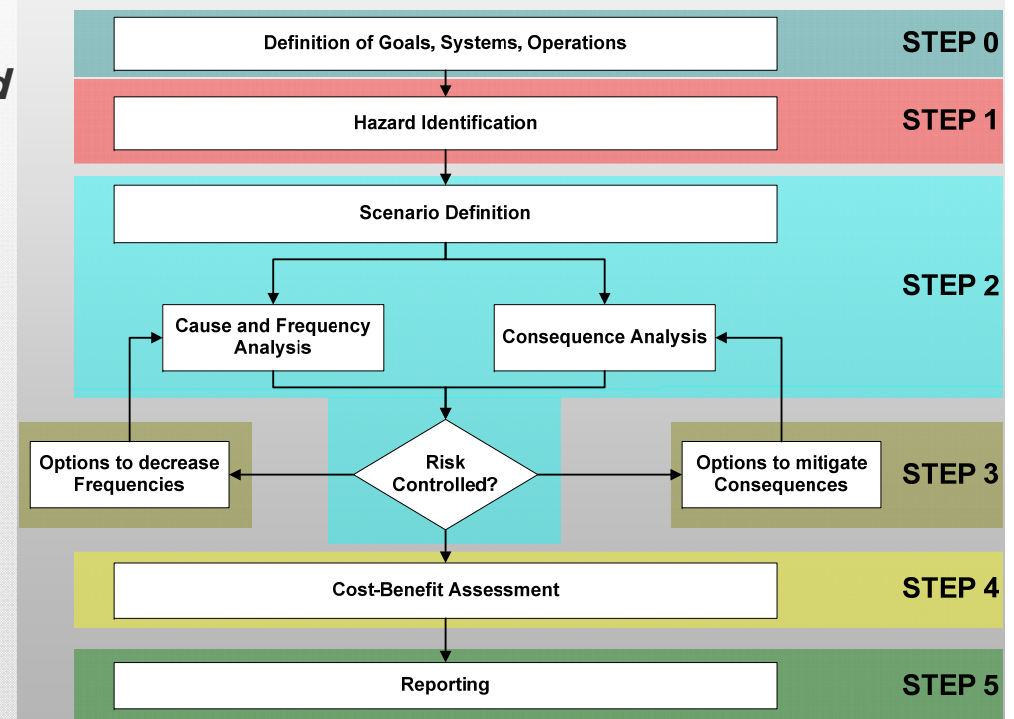
- IMO has already started to revise or develop regulations taking onboard the idea of GBS, e.g.:
  - Polar Code
  - IGF
  - LSA (re-structure and introduce goals and functional requirements)
- However:
  - There is no common style and approach in this work (missing guidelines!)
  - No clear anchoring for goals and functional requirements (ones in the Code, in each Chapter or somewhere else)
    - No clear idea how to formulate functional requirements
    - Too prescriptive Code: functional requirements pushed in the background
  - No “background” risk models exist (some HazIds carried out)

# FSA: risk-based development of regulations

- Formal Safety Assessment (FSA): FOR USE IN THE IMO RULE-MAKING PROCESS

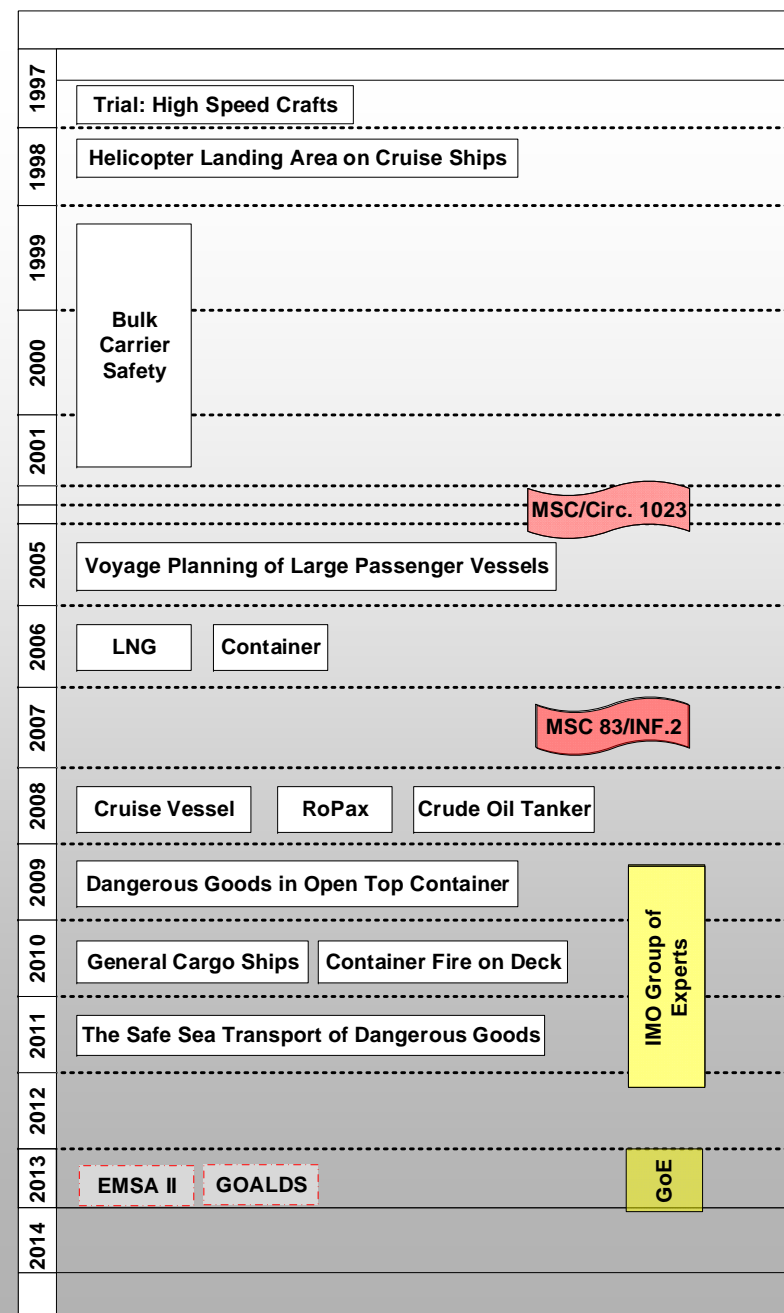


- IMO developed Formal Safety Assessment in order to *apply scientific methods to manage and reduce risks (MSC 62/24/3)*
- Standard risk assessment process amended by cost-benefit assessment and reporting
- Central part of FSA is risk assessment:
  - determination of risk level
  - assessment of current risk level
- Risk models quantify effect of risk mitigating measures (risk control options)

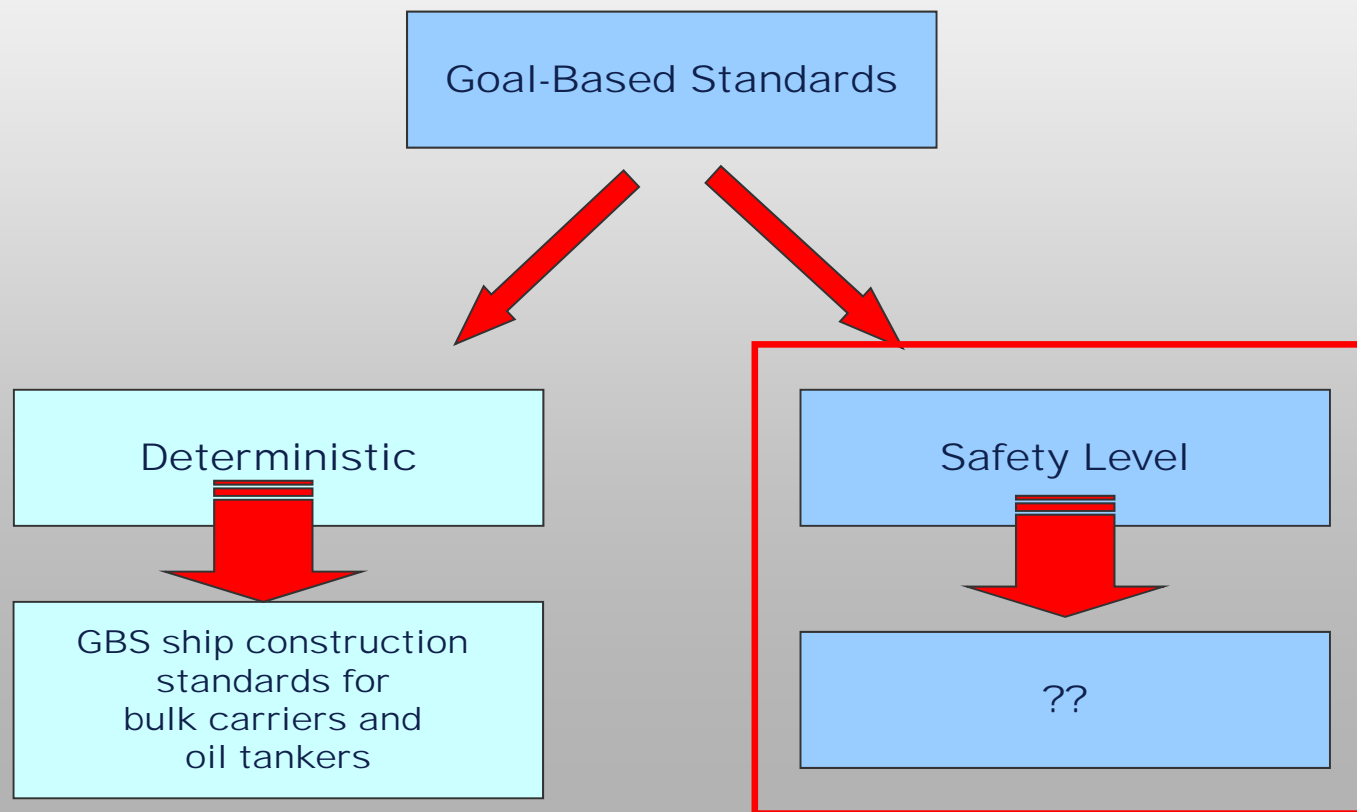


# FSA "Story"

- Since 1997 different teams performed FSAs
- Meanwhile risk models for all major ship types developed by FSAs:
  - Bulk carrier
  - Tanker (crude oil, LNG)
  - Containership
  - Cruise
  - RoPax
- As well as for single aspects
- Current risk models consider mainly scenarios between incident and consequences



## Current state of GBS/GBS-SLA discussion



# Current State of GBS: Where do come from

## PHASE I

MSC 82

- GBS on the agenda
- Requirements:
  - *What* instead of *how*
  - rules for rules (& regulations)
- Two basically different approaches

### Deterministic

- GBS ship construction standards for bulk carriers and oil tankers had been agreed
- Class rules will be submitted for verification (IACS common Structural rules):
  - end 2013 (individual rules + IACS resolutions)
  - mid 2014 for structural rules

### Safety level

- Discussion on various elements of GBS-SLA
  - Statistical data
  - Ship types
  - Linkage FSA – GBS
  - Structural reliability analysis
  - High level functions

## PHASE II

MSC 88

Generic GBS Guidelines

# Current State of GBS: Where do come from

MSC 88

PHASE III

- Generic Guidelines For Developing IMO Goal-Based Standards (MSC.1/Circ. 1394, 2011)
- Discussion:
  - Focus: develop GBS-SLA
  - Topics:
    - Use safety instead of risk (easier to accept by society)
    - Discussion was focussed on high level aspects, e.g.:
      - can we rely on risk-based methods?
      - do we have sufficient data for monitoring and using risk-based methods?
      - relation between Formal Safety Assessment and GBS-SLA (again/still)

ONLY SMALL PROGRESS



# Current State of GBS<sub>3</sub>

- Additionally, progress in discussion after MSC 86 negatively influenced by also considering other topics under this agenda item:
  - some aspect related to deterministic GBS (e.g. ship construction file, verification scheme)
  - update of FSA Guidelines
  - development of guidelines on approval of alternative design and equivalences



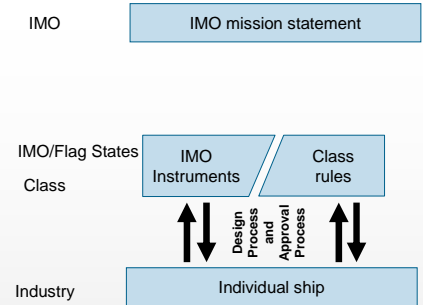
- limited number of submissions ~ GBS-SLA
- small progress

# Current State of GBS<sub>4</sub>

- Generic Guidelines For Developing IMO Goal-Based Standards (MSC.1/Circ. 1394, 2011):
  - independent from approach taken (deterministic or risk-based)
  - contains elements of GBS that are agreed (results of the discussion), like
    - some definitions
    - basic principles
    - verification of conformity
    - monitoring
  - But contains no proposal how goals

**No relevant input for developing GBS-SLA!**

**Shortcomings demonstrated by IGF Code and Polar Code**



The diagram illustrates the IMO goal-based standards framework, showing the flow from high-level goals to specific industry practices, with associated monitoring and feedback loops.

**Goals (Tier I)** (Top box) leads to **Functional requirements (Tier II)** (Second box), which leads to **Verification of conformity (Tier III)** (Third box).

**Verification of conformity (Tier III)** leads to **Rules for ships e.g. IMO requirements, classification rules, relevant national requirements (Tier IV)** (Fourth box).

**Rules for ships (Tier IV)** leads to **Industry standards and practices (Tier V)** (Bottom box).

**Monitoring of IMO goal-based standards** (Left box) is linked to **Goals (Tier I)** and **Functional requirements (Tier II)** via a double-headed arrow.

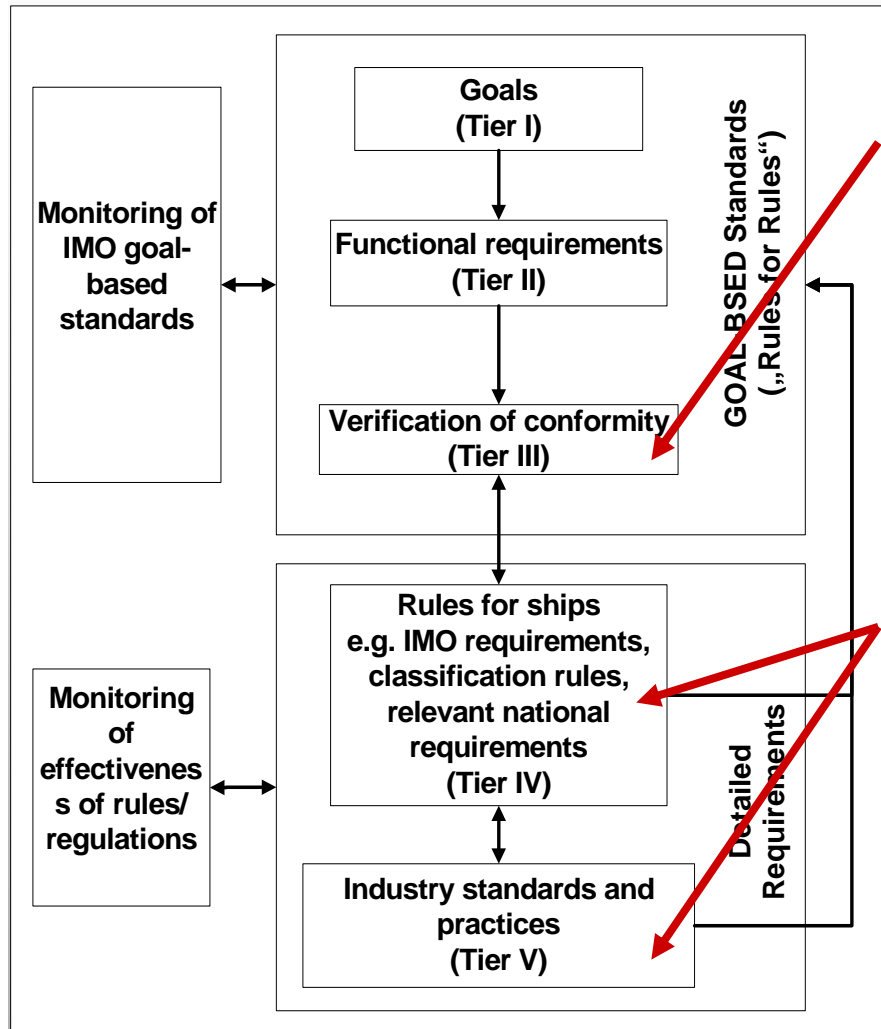
**Monitoring of effectiveness of rules/regulations** (Left box) is linked to **Rules for ships (Tier IV)** and **Industry standards and practices (Tier V)** via a double-headed arrow.

**GOAL-BASED Standards („Rules for Rules“)** (Right box) is linked to **Goals (Tier I)** and **Functional requirements (Tier II)** via a double-headed arrow.

**Detailed Requirements** (Right box) is linked to **Rules for ships (Tier IV)** and **Industry standards and practices (Tier V)** via a double-headed arrow.

Red arrows indicate feedback loops from **Functional requirements (Tier II)** back to **Goals (Tier I)** and from **Verification of conformity (Tier III)** back to **Functional requirements (Tier II)**.

# Current State of GBS<sub>6</sub>: verification and monitoring



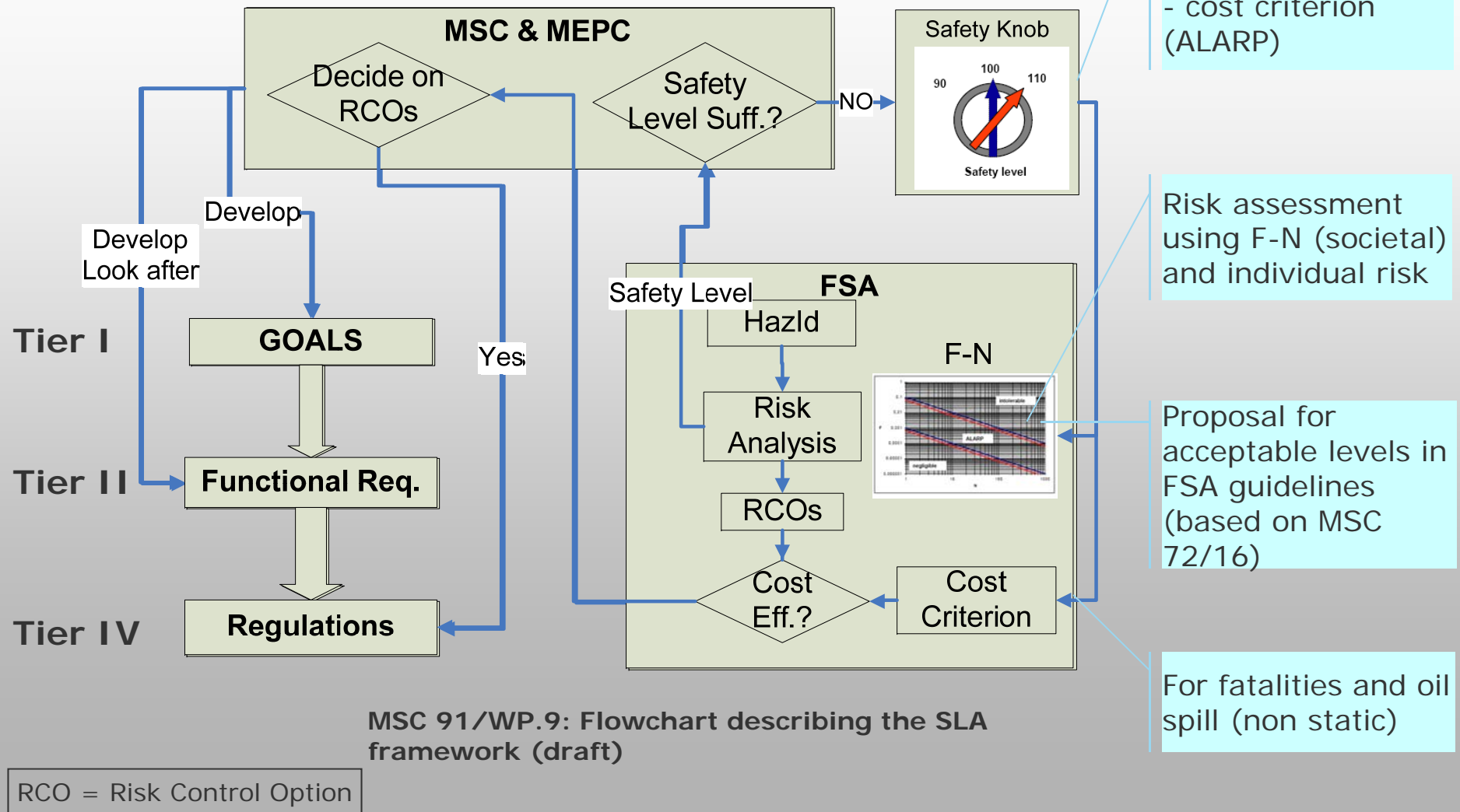
- **Verification of conformity (Tier III):**
  - process of (quality assurance) and part of standard
  - check if all relevant functional requirements were addressed
  - requirements for documentation
- **Rules, regulations (Tier IV) and industry practices and standards (Tier V)**
- **New: monitoring for evaluating effectiveness of Tier I, II, IV and V**

## Current State of GBS<sub>7</sub>: Linkage between GBS-SLA and FSA

- GBS-SLA shall use risk-based methods to develop and adjust regulations and rules
- FSA uses risk analysis to support IMO decision making
- In FSA process:
  - implicit safety level of IMO provisions is determined (current risk for crew, passengers and environment)
  - evaluation of current safety level by comparison with other industries
  - using cost-benefit assessment for continuously improving safety

Not new: aspects already mentioned in  
CG report MSC 83/5/3

# GBS-SLA and FSA



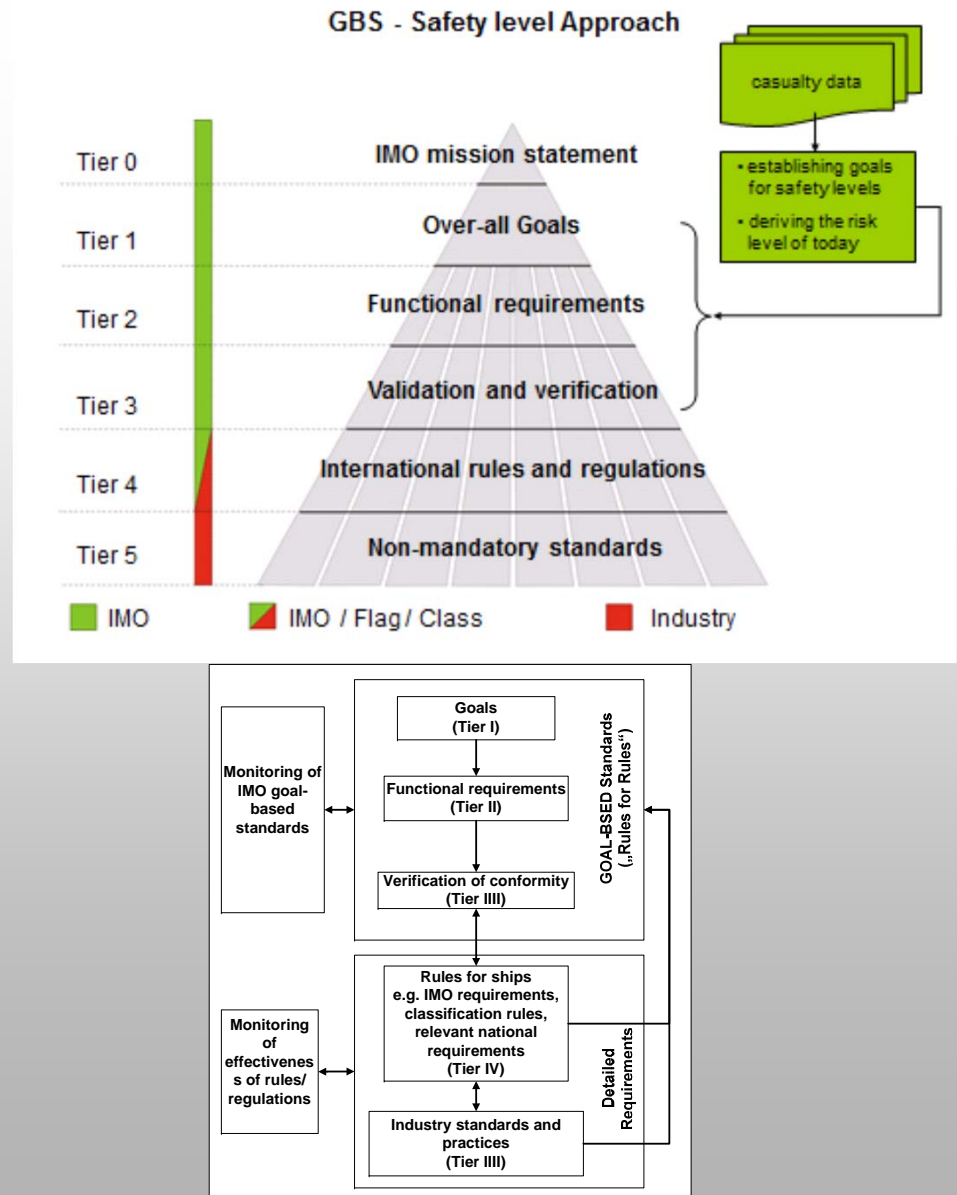
# Drafting GBS-SLA

[what exists – what is needed]

# Drafting GBS-SLA

- GBS-SLA consists of:
  - Goals
  - Functional requirements
  - [model(s) specifying relation between func. req. and specific reg.]
  - Process for justification of regulations and rules
    - [ALARP]
    - [Thresholds for justification]
    - [agreed risk models]
  - [specification for minimum safety levels for “regulation areas” (balancing)]

**ALARP: As Low As Reasonable Practical**



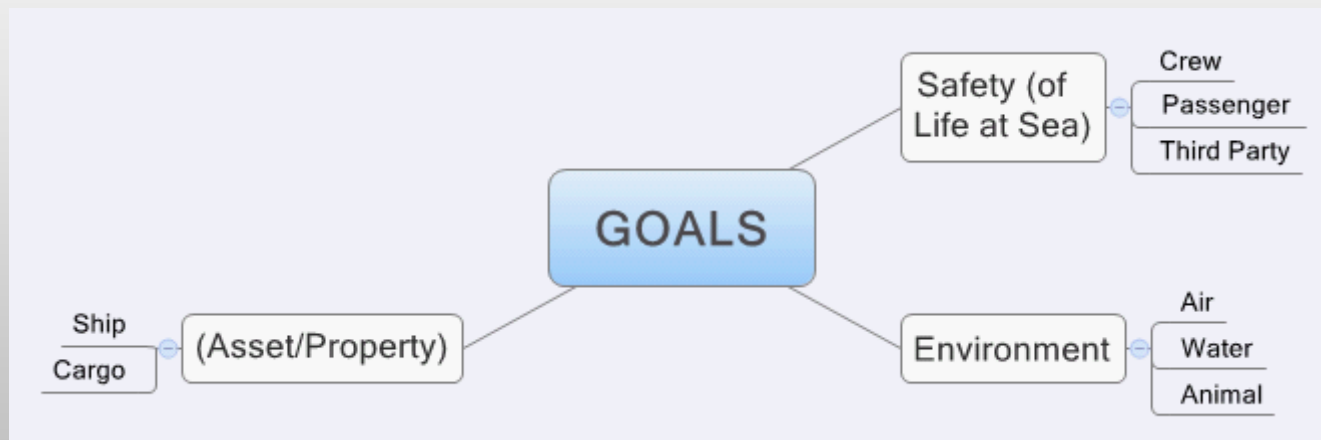


# Drafting GBS-SLA

- GBS-SLA is **not** a safety case
- GBS-SLA is *rules for rules* (and *regulations*):
  - specifying the structure of regulations and the way of development
  - specify a safety level and a process to verify compliance with this level
- Therefore, with GBS-SLA in place it is expected that
  - most ship design will be still based on prescriptive rules and not risk-based design
  - in general survey and port state control will not change for majority of ships (like today considering alternative design)

# Drafting GBS-SLA: Goals

- Goals:
  - high-level objectives to be met. A goal should address the issue(s) of concern and reflect the required level of safety.



- But: how to specify goals:
  - To what level of detail (granularity)
  - Quantitative or qualitative (IMO may use ALARP for regulations)


# Drafting GBS-SLA: Functional Requirements<sub>1</sub>

- Functional requirements should
  - provide the criteria to be satisfied in order to meet the goals
  - cover all functions/areas necessary to meet the goal
  - be specified considering experience, assessment of existing regulations and/or systematic analysis of relevant hazards
- establish relation between specific requirements and goals

Result of CG work



# Drafting GBS-SLA: Functional Requirements<sub>2</sub>

- Functional requirements specify the aspired safety level in more detail:
  - what should be addressed to comply with goals (what must be analysed in Alternative Design)
  - however: what means compliance?
- Furthermore:
  - thresholds may be specified for each function
    -  thresholds can be used for Alternative Design (equivalent safety)
  - not only one “layer” of functional requirements
  - should be amended by
    - boundary conditions (under which conditions this function shall be provided)
    - performance requirements (what is sufficient manoeuvrability – acceptance scenarios)

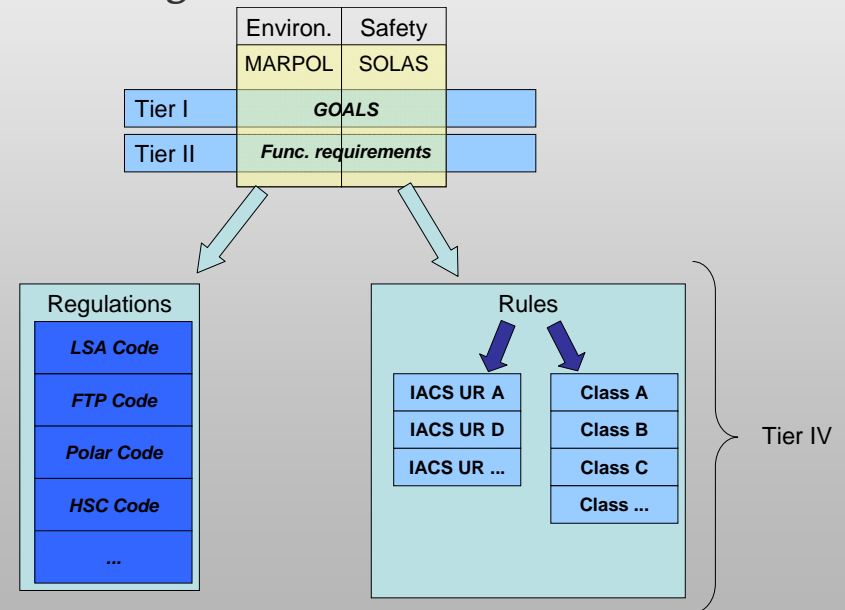
# Drafting GBS-SLA: Functional Requirements<sub>3</sub>

- Examples (SOLAS II-2):
  - Division of the ship into main vertical and horizontal zones by thermal and structural boundaries;
  - Separation of accommodation spaces from the remainder of the ship by thermal and structural boundaries;
  - **Restricted use of combustible materials;**
  - Detection of any fire in the zone of origin;
  - **Containment and extinction of any fire in the space of origin;**
  - Protection of means of escape and access for fire-fighting;
  - Ready availability of fire-extinguishing appliances; and
  - Minimization of possibility of ignition of flammable cargo vapour

# Drafting GBS-SLA: Drafting GBS-SLA

- **Structure of functional requirements**

- Should follow a functional breakdown of ship and ship systems
- Functional breakdown can provide basis for new structuring of IMO provisions
- Until now only some high level functions were *agreed*



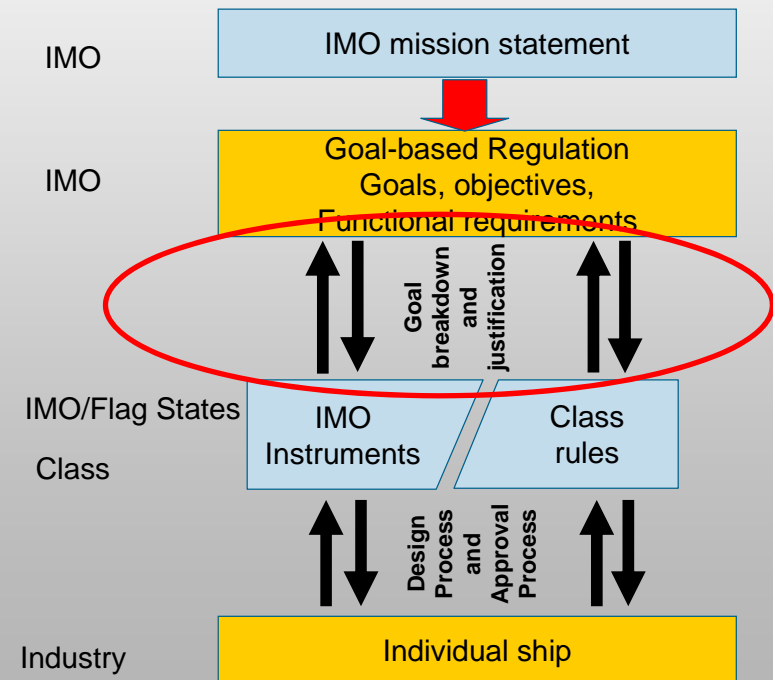
e.g. MSC 90/5/2

# Drafting GBS-SLA: Tier III

- Process element of GBS-SLA: justification of regulations and rules

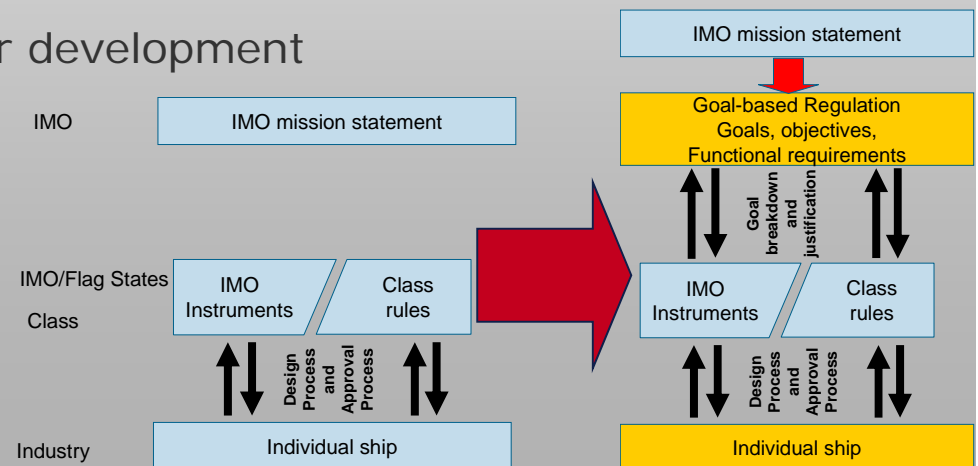
$$R_{Regulation} \leq R_{GOAL}$$

- For quantitative justification:
  - [agreed “risk models”]
  - [agreed input data]
- Risk models will allow to demonstrate effect(iveness) of regulations and rules



# The way towards GBS-SLA

- Results of the discussion in the first phase of GBS development demonstrate the need for applying a step-by-step approach limiting discussion to single aspects
- Due to the fact that no “unique” solution exists favourably examples should be developed:
  - identification of issues and their solution
  - agreeing the structure “step-by-step” (next step: agree on formulation and placing of functional requirements)
  - participation of all stakeholders and not only “experts”
  - produce a “blueprint” for the further development
- GBS-SLA development will be
  - an iterative process
  - combined with a transition phase





# Summary & Outlook

- Current regulation follow the technological development
- Due to increasing speed of technological development, it is a challenge for regulator to follow
- Goal-Based Standards are an alternative to current regulation:
  - specifying what shall be achieved rather than how
- GBS-SLA requires the application of risk-based methods for justification of regulations and rules
- Functional breakdown will provide a clearer structure of regulations (avoidance of *unwanted side effects*)
- GBS-SLA is a new structure of IMO framework which has to be agreed by all stakeholders
- The development of GBS-SLA is a **long-term process** (step-by-step)

# Thank You For Your Kind Attention!

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