

# **Novel Trends in Risk Analysis in Shipping**

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# Contents

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- Introduction (main drivers)
- Risk based approaches currently employed
  - ◆ Risk analysis of complex systems
  - ◆ Evacuation analysis
  - ◆ Verification
  - ◆ Integrated Safety Management System
- Findings
- Conclusions

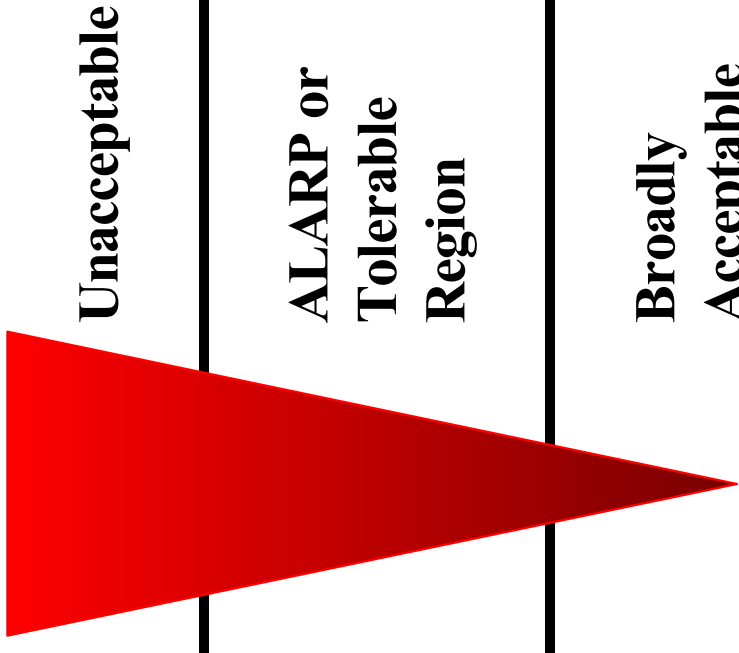
## Risk Based Drivers

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- In 1993 the UK Marine Safety Agency proposed to the IMO that Formal Safety Assessment (FSA) could be applied to ensure a strategic oversight of safety and pollution prevention
- ISM Code explicitly requires:
  - ◆ Safeguards to be established against all identified risks
  - ◆ That a company can respond at any time to hazards, accidents and emergency situations involving ships
- Disasters such as Sea Empress, Erika, Prestige, etc.

# UK Safety Legislation

- Safety legislation in the UK requires demonstration that risks are **As Low As Reasonably Practicable (ALARP)**
- Risk Tolerability Doctrine has been developed in the UK to reflect and enhance the **goal setting approach to safety and ALARP**

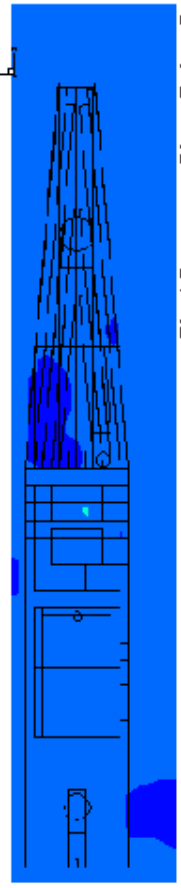
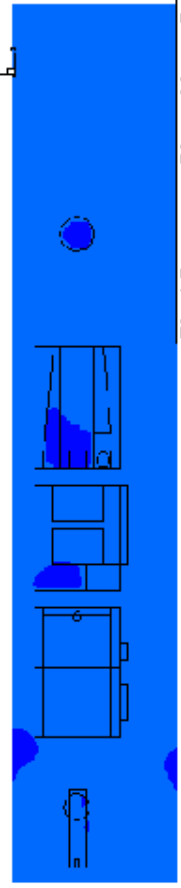
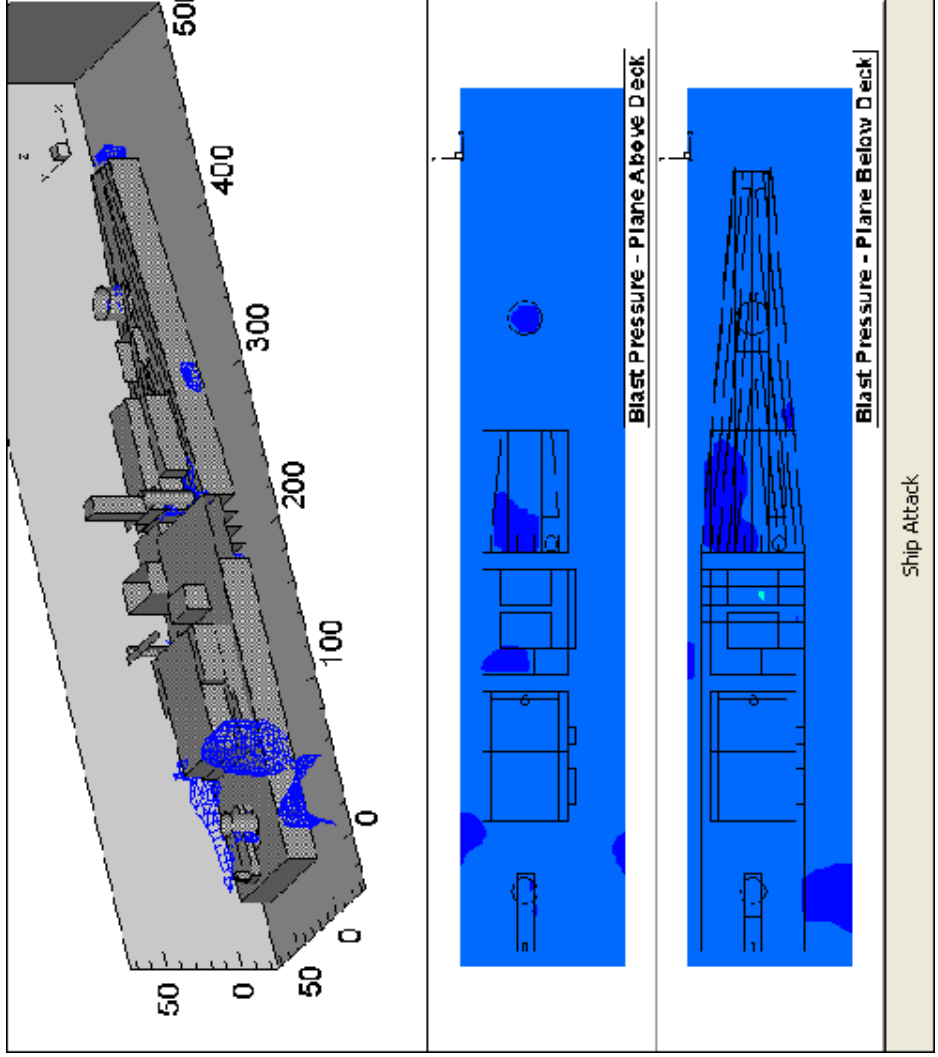


## Risk Based Approaches Being Explored

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- Safety Case type demonstration of how safety has been considered and incorporated into the design or modification of a vessel (this comprise of risk assessment and the SMS)
- Risk based inspection surveys
- Risk/reliability assessment of complex systems (e.g. propulsion, steering, etc.)
- Development of verification scheme for the safety critical elements
- Introduction of risk based Safety Management System

# Another Driver ?



Ship Attack

## Safety Case Approach

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### *Requires demonstration that:*

- All hazards with the potential to cause a **major accident** have been identified
- Risks have been evaluated and measures have been, or will be, taken to reduce the risks to persons affected by those hazards to the level as low as **reasonably practicable** (ALARP)

### *Components of a Safety Case*

- Formal Safety Assessment
- Safety Management System

# Operational Safety Case



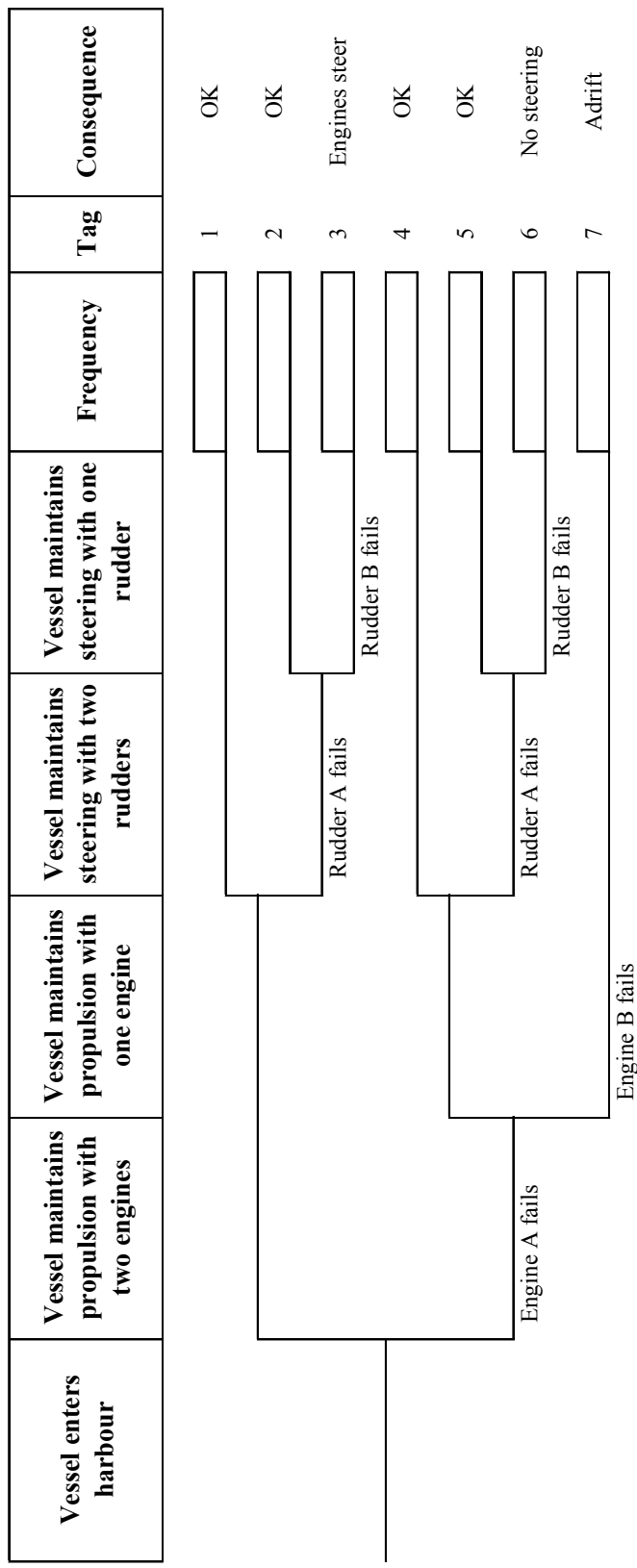


## Risk Analysis of Complex Systems

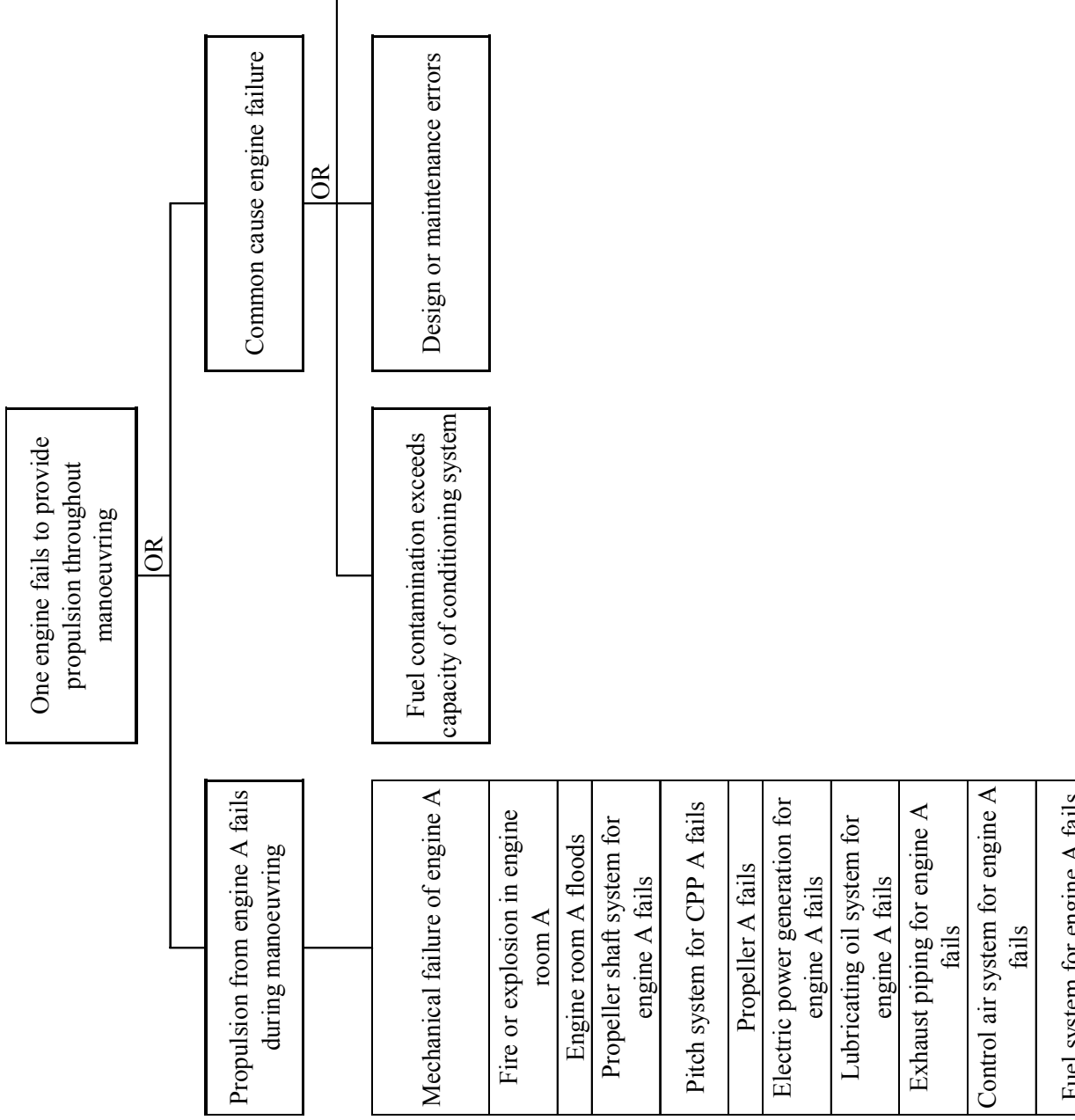
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- The main driver is the reduction in business interruption and the overall risk by improving the reliability of complex systems
- Example shows the effect of having redundant systems and how these systems provide additional protection against mishaps

# Event Tree for Enhanced Tanker



# Fault Tree for Loss of Propulsion



# Escape and Evacuation Assessment

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## *Important for passenger vessels*

- Objective is to evaluate the adequacy of arrangements for getting people from the vessel to a place of safety
- The provisions for E&E are analysed with respect to the major accidents scenarios (identified in risk analysis) and compared with acceptance standards
- Deficiencies in escape and evacuation are identified and rectified

## Typical Scope of Work for E&E

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- Identify major accident events requiring E&E
- Classify the accident events to include:
  - location of accident, effects, time available
- Evaluate measures of performance of the E&E systems including: time dependent development of scenarios, muster time, success of lifeboat launch under different weather conditions
- Consider how E&E systems will perform under a range of accident scenario demands
- This is complemented by fire risk and smoke propagation analyses

## Verification Approach

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In the offshore industry, instead of assuring the adequacy of the installation's design and equipment by **certification (classification)**, the new system of **verification** requires the identification of the elements of the installation which are critical to its safety and then checking their condition and performance by competent and independent persons

## Safety Critical Elements

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Safety Critical Elements are such parts (systems, components) of an installation or its plant (including computer programmes),

- ◆ the failure of which could cause or contribute substantially to major accident, or
- ◆ a purpose of which is to prevent or limit the effects of such accidents

# Components of Verification

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- Structured approach to identification of Safety Critical Elements (risk assessment)
- Assessment of criticality of SCE
- Setting the Performance Standards
- Development of Verification Scheme



## Need for Verification

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### *ISM Code explicitly requires:*

- The Company should establish procedures in its SMS to identify **equipment and technical systems the sudden operational failure of which may result in hazardous situations**
- The SMS should provide for specific measures aimed at **promoting the reliability of such equipment or systems, ...the** measures should be integrated in the ship's operational maintenance routine

# Port Marine Safety Code



**Risk Support**

## Port Marine Safety Code

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### *Key requirements:*

- Harbour authority board members are **collectively accountable and individually responsible** for the proper exercise of their authority's statutory functions
- Harbour authorities must have formal **Safety Management System (SMS)**
- The aim of a SMS is to ensure that all risks are tolerable and **as low as reasonably practicable**

## Need for the Management System

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*Degradation of safety margins due to the absence of SMS:*

- Deterioration of the equipment quality
- Dilution of skills as the experienced personnel are replaced by inexperienced personnel
- Increases in demand on personnel
- Erosion of established practices due to commercial pressures
- Complacency and misplaced confidence because of absence of accidents

## Risk Analysis and SMS

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### *Important issues:*

- **Underlying causes** of operator failure have in many cases been traced back to the management and organisation of the industrial activities
- **Analysis of management and organisation** of activities is not easily incorporated into the overall risk model
- **Transfer of information** from risk assessment into management control remains an area of improvement

## Active Risk Management (iSMS)

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### *Objectives:*

- Risk assessment to be easily understood by all
- To establish suitable risk controls to manage risks
- Accountability and responsibility for the identified risk controls is well defined and distributed
- Every member of the crew to know how are his tasks linked to hazard management
- To facilitate demonstration to stakeholders that risks are as low as reasonably practicable

## An Interesting Note

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*Control of Major Accident Hazards  
(COMAH) Regulations in the UK  
(Seveso 2 Council Directive 96/82/EC)*

“adequate safety and reliability have been incorporated into the design and construction, and operation and maintenance of any installation - and equipment and infrastructure connected with its operation - **and linked to major accident hazards** within the establishment ...”

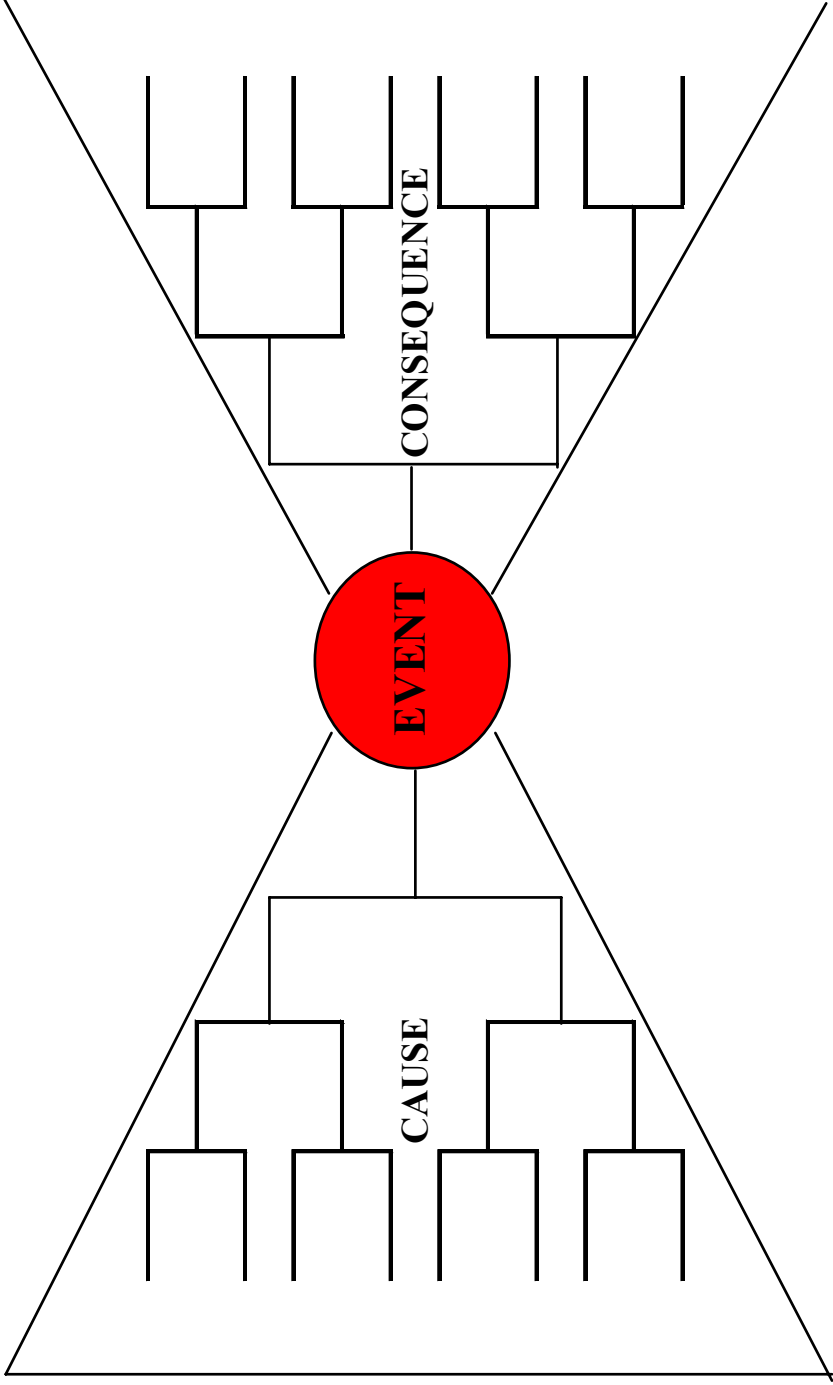
# Main Tasks of Active Risk Management

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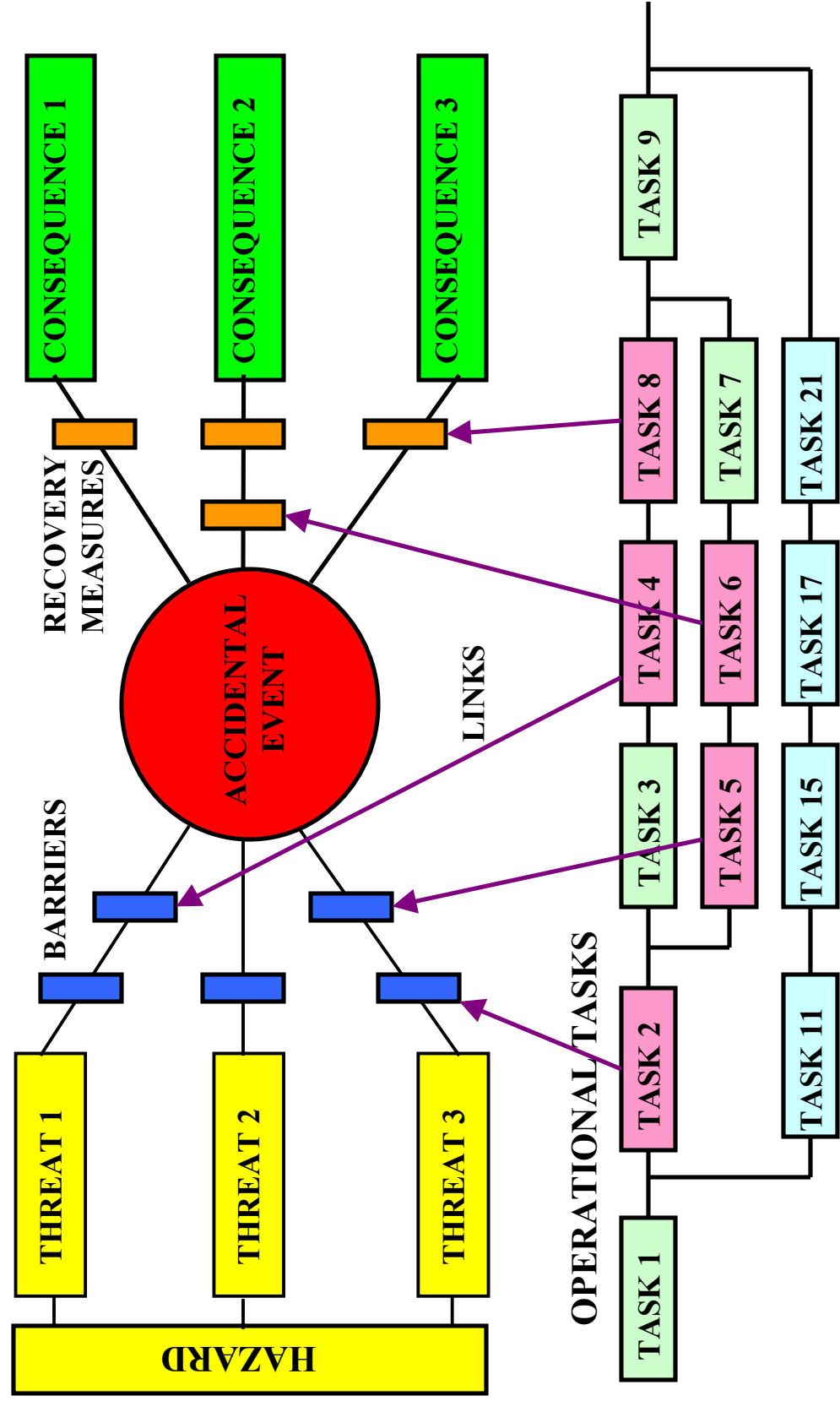
- System definition
- Hazard identification
- Risk assessment (**causes and effects - not numbers!**)
- Establish risk controls
- Link risk controls to personnel activities and tasks
- Manage activities and tasks within iSMS



# Cause – Consequence Diagram



# Essence of iSMS Model

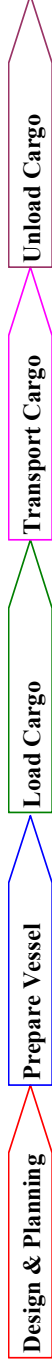


## System Definition

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- Familiarisation with the vessel
- Vessel crew and management
- Defining vessel processes
- Defining personnel tasks
- Confirmation of the goals of the analysis

# Vessel Processes



Activity	Execution processes			Owner
B1	Engineering design and planning			ME
B2	Vessel preparation			GMFO
	Prepare for transport			
B3		Cargo loading		MCO
B4			Voyage planning	MCO
			Organisation on board the vessel	
B5			Cargo unloading	MCO
<b>Activity</b>	<b>Operations Support Processes</b>			<b>Owner</b>
C1	Provide technical, marine and logistics support			GMFO
C2	Provide financial services			MFA
C3	Provide human resources			GMPO
C4	Provide communication and information technology services			SSA
C5	Provide maintenance			GMFO
C6	Provide vessel inspection and survey			GMFO
C7	Crew training			GMPO
<b>Activity</b>	<b>Management Processes</b>			<b>Owner</b>
A1	Manage company business			MD
A2	Manage corporate management system			MD
A3	Manage health, safety environment protection and quality			MQS
A4	Manage contracts			GM
A5	Manage projects			PM

# Process Model

Activities	Port of Sunderland Processes																		
	Pre-arrival notification	Vessel scheduling	Arrival at Eastern limit	Pilotage	Tug escort	Approach to lock entrance	Lock operations	Berthing	Disconnection of tugs	At berth during cargo operations	Pilot boarding and clearance for departure	Connection of tugs	Unberthing	Lock operations	Outward voyage	Departure of tugs	Departure of pilot	Sailing out of port limits	
MANAGE PORT OF SUNDERLAND																			
MANAGE OPERATIONS																			
MANAGE ASSETS																			
MANAGE MARINE SERVICES																			
PROVIDE NAVIGATION SERVICE																			
Vessel information gathering and scheduling																			
Establish tidal restrictions for vessel draught and air draught																			
Monitor vessels in the Channel																			
Provide assistance to pilots, masters and skipper																			
Enforce by/laws, general and special directions																			
Interface with berths																			
Manage vessels at anchor																			
Compliance with Emergency Plans																			
Plan and manage vessels for bridge transit																			
Bunkering operations																			
Prepare for special events																			

# Process Model

Activities	Pre-arrival notification	Vessel scheduling	Arrival at Eastern limit	Pilotage	Tug escort	Approach to lock entrance	Lock operations	Berthing	Disconnection of tugs	At berth during cargo operations	Pilot boarding and clearance for departure	Connection of tugs	Unberthing	Lock operations	Outward voyage	Departure of tugs	Departure of pilot	Sailing out of port limits
<b>PROVIDE PILOTAGE SERVICE</b>																		
Vessel information gathering and scheduling		Blue																
Planning act of pilotage		Blue															Blue	
Embarking and disembarking			Blue															
Assessing standards on piloted vessel			Blue															
Co-operating with the bridge team and functioning within it																		
External communications																		
Establish tidal restrictions for vessel draught and airdraft clearance			Blue															
Testing the vessel (if powered)				Blue														
Conduct of the vessel/transiting the pilotage district																		
Manoeuvring vessels in different locations and conditions																		
Interact with tugs																		
Provide berthing/unberthing advice																		
Comply with bylaws and directions																		
<b>PROVIDE TOWAGE SERVICE</b>																		
Schedule to wage		Green																
Tug operations																		
Contingency operations																		



# Hazard Identification

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A major hazard is defined as a physical situation or condition with the **potential to cause harm**, including injury and fatality, damage to the environment and/or assets, business interruption, or increased liabilities



# Accidental Events

No.	Hazard Category	Accidental Event
C.01	Impacts and collisions	Vessels in close quarters situation
C.02	Impacts and collisions	Approaching Piers in hazardous manner
C.03	Impacts and collisions	Small craft on collision course
C.04	Impacts and collisions	Breaching safe distance to vessel at berth
D.01	Dock/quayside related hazards	Loss of water level in dock
D.02	Dock/quayside related hazards	Striking equipment at berth
D.03	Dock/quayside related hazards	Vessel settles at dock bottom
D.04	Dock/quayside related hazards	Vessel settles at river bed
D.05	Dock/quayside related hazards	Vandalism - moorings cut
D.06	Dock/quayside related hazards	Bunkering spill
F.01	Fires and explosions	Fire on vessel
F.02	Fires and explosions	Compartment fire
F.03	Fires and explosions	Cargo tank fire
F.04	Fires and explosions	Fire on DG vessel
F.05	Fires and explosions	Chemical fire and/or spill

# Accidental Events

No.	Hazard Category	Accidental Event
M.01	Manoeuvring	Failure in swinging the vessel
M.02	Manoeuvring	Failure in manoeuvring at dock entrance
M.03	Manoeuvring	Approaching dock with gates/bridge not opened
M.04	Manoeuvring	Berthing error
M.05	Manoeuvring	Unberthing error
M.06	Manoeuvring	Entering/Leaving port with restricted draught
M.07	Manoeuvring	Loss of steering
M.08	Manoeuvring	Loss of propulsion
M.09	Manoeuvring	Manoeuvring in the middle basin
N.01	Navigation	Navigational error
N.02	Navigation	Error during transit
N.03	Navigation	Sailing in area of restricted draught
N.04	Navigation	Failure to keep air clearance
P.01	VTS related	VTS communication failure
P.02	VTS related	Failure of VTS Operator to maintain post

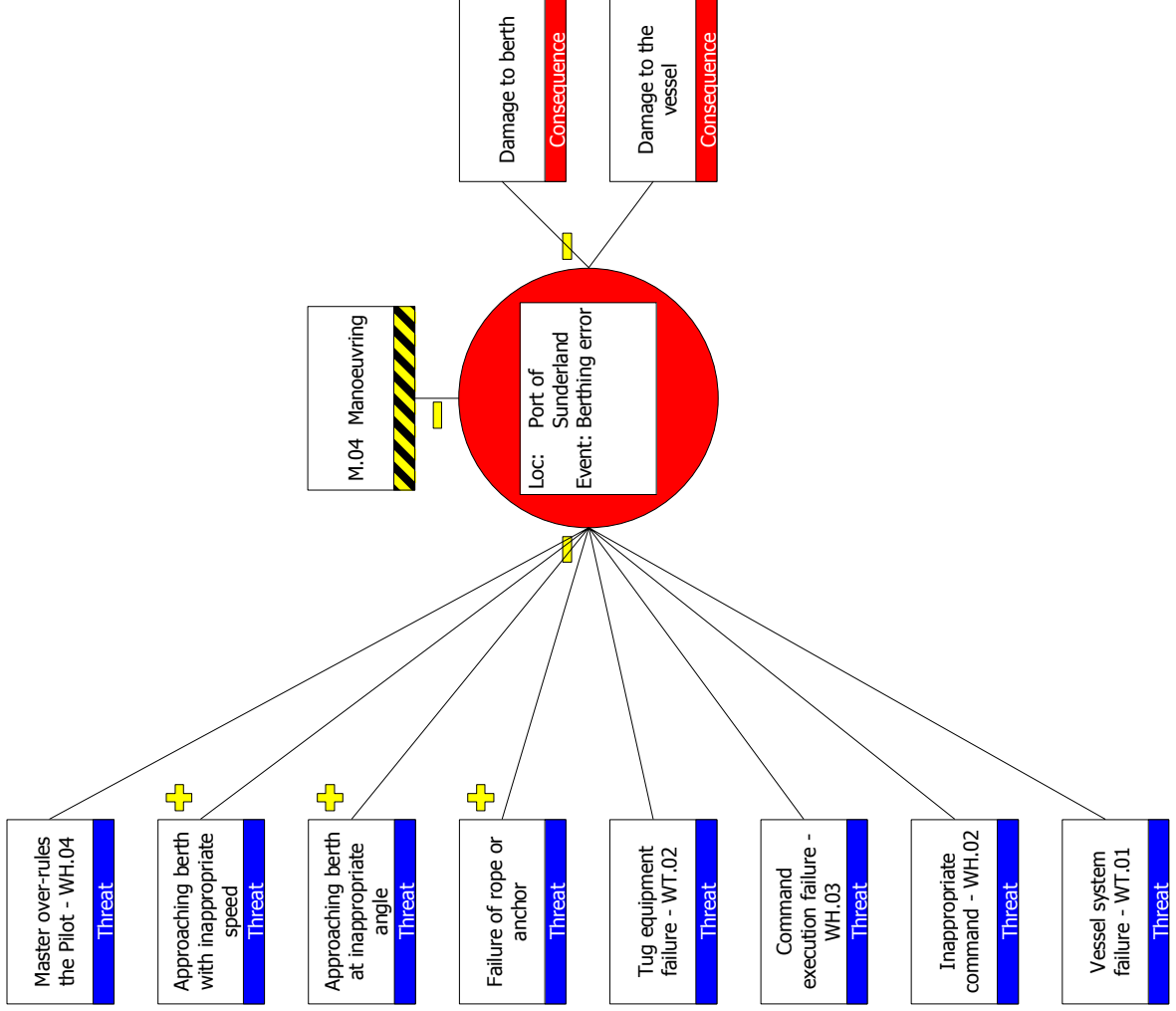
# Accidental Events

No.	Hazard Category	Accidental Event
P.03	VTS related	Power failure
R.01	Interface hazards	Loading / unloading failure
R.02	Interface hazards	Drop of load onto the ship
T.01	Tug related	Insufficient tugs used
T.02	Tug related	Endangering the tug
T.03	Tug related	Towline failure (drifting barge)
V.01	Vessel related	Vessel obstructing waterways
V.02	Vessel related	Unauthorised movement from berth
V.03	Vessel related	Rogue vessel
V.04	Vessel related	Ship movement during cargo operations
V.05	Vessel related	Mooring failure
V.06	Vessel related	Anchoring failure
V.07	Vessel related	Watchkeeping failure
V.08	Vessel related	Vessel flooding (all causes)
V.09	Vessel related	Vessel not under command
V.10	Vessel related	Vessel undermanned

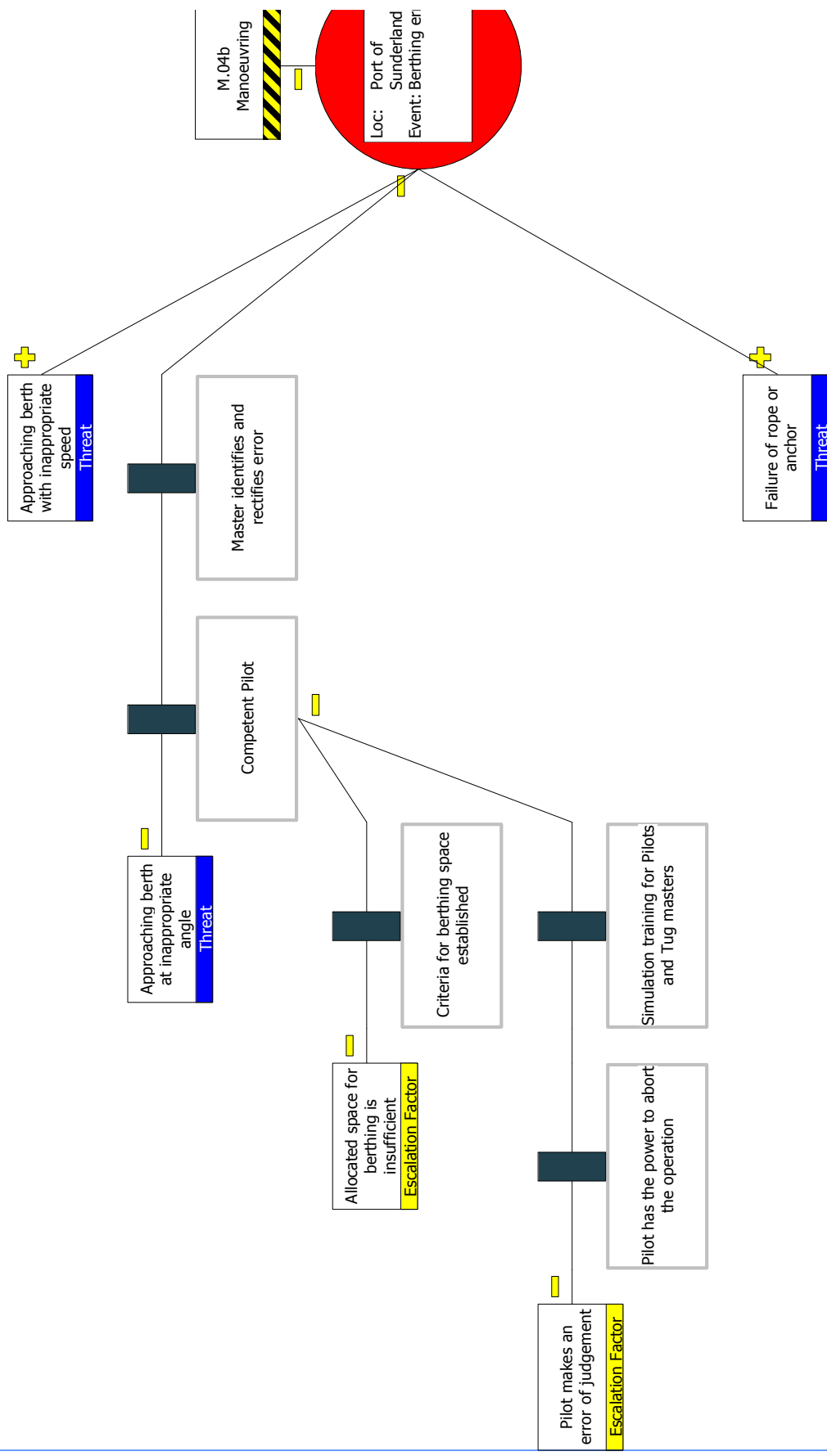
# Generic Events

No.	Hazard Category	Accidental Event
WH.01	Human Factors hazards	Manoeuvre planning error
WH.02	Human Factors hazards	Inappropriate command
WH.03	Human Factors hazards	Command execution failure
WH.04	Human Factors hazards	Violation of best practice
WH.05	Human Factors hazards	Incorrect command due to position assessment error
WH.06	Human Factors hazards	Inaccurate position assessment
WH.07	Human Factors hazards	Inattention to position
WH.08	Human Factors hazards	Failure to compensate for weather effects
WT.01	Generic hazards	Vessel system failure
WT.02	Generic hazards	Tug system failure
WT.03	Generic hazards	Vessel flooding
WW.01	Generic weather hazards	Unexpected weather conditions
WW.02	Generic weather hazards	Operations in poor visibility
WW.03	Generic weather hazards	Operations in large swell
WW.04	Generic weather hazards	Operations in extreme winds
WW.05	Generic weather hazards	Operations in strong currents

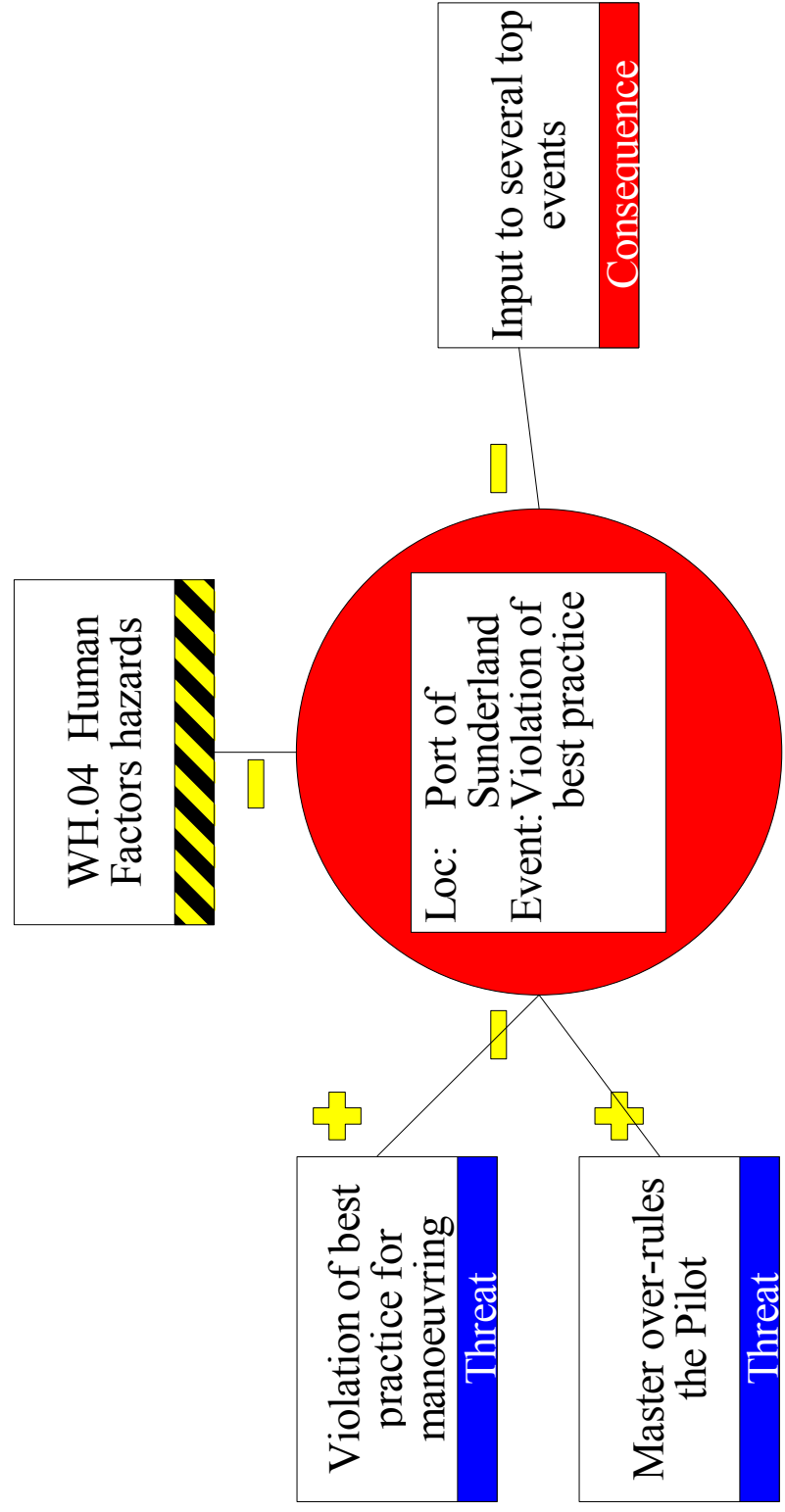
# Berthing Error Event



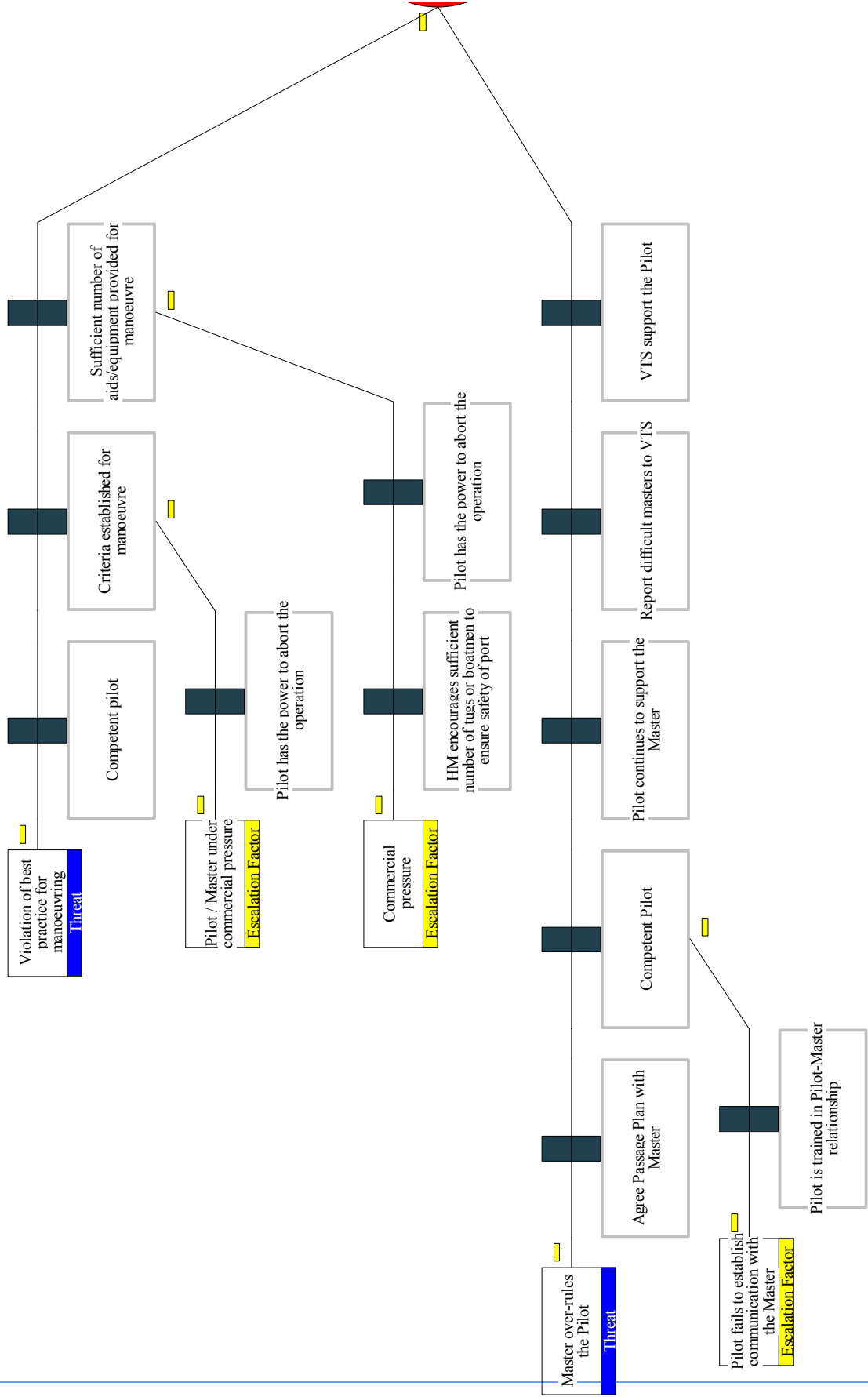
# Barriers and Escalation Factors



# “Generic Threats”



# Generic Threat





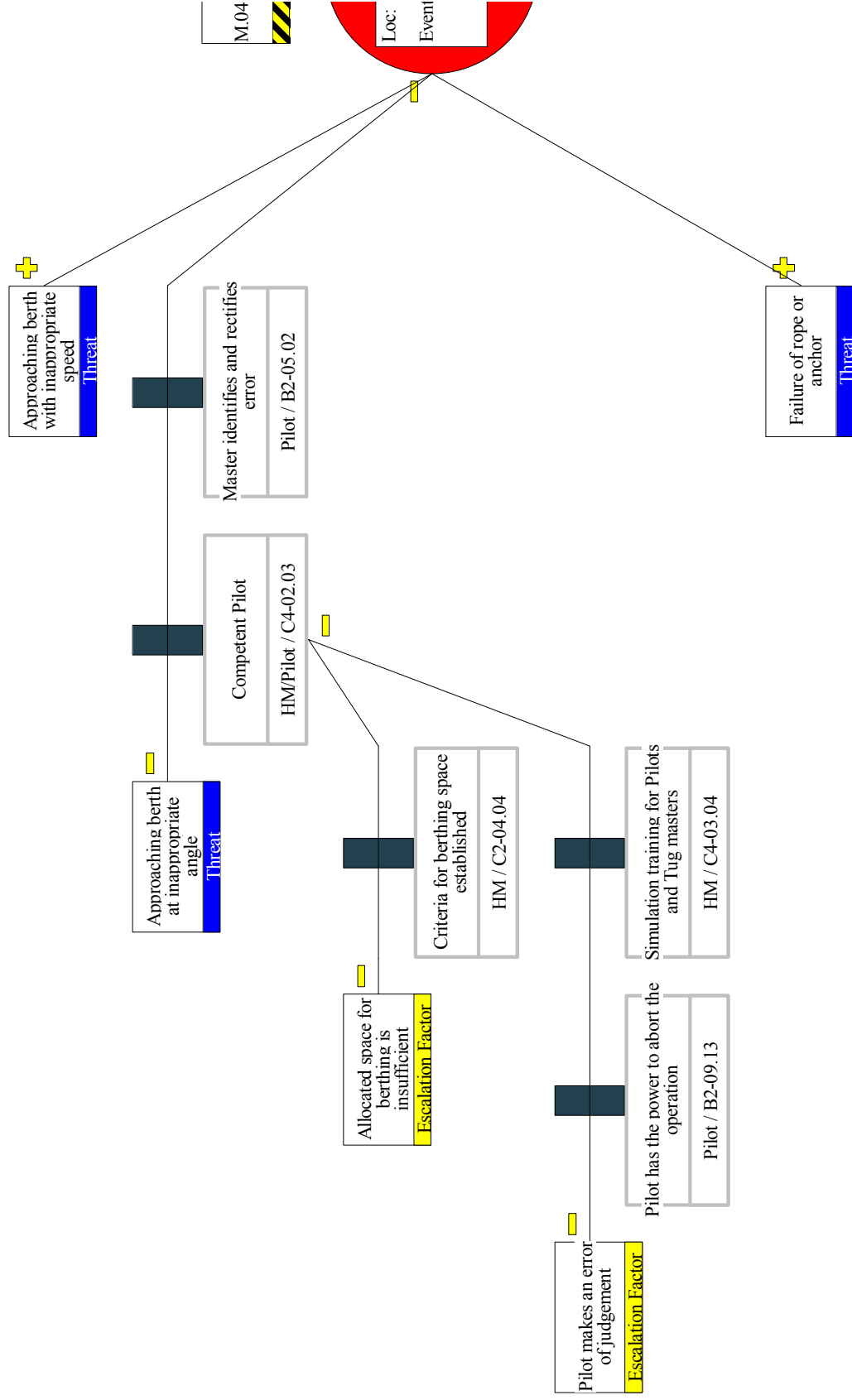
# Activities and Tasks

No.	Activities / Tasks	Post Indicator
<b>B1-01</b>	<b>Vessel information gathering and scheduling</b>	<b>VTS</b>
B1-01.01	Receive information about vessel ETA/ETD	VTS
B1-01.02	Input information into records	VTS
B1-01.03	Check vessel DG information and notify Fire Brigade of class 1 cargo	VTS
B1-01.04	Record if vessel has declared defects and pass to pilots	VTS
B1-01.05	Question the vessel if they have prepared a Passage Plan and check that they have checked	VTS
B1-01.06	Inform Pilots and at 2 hours before ETA (or less as required by Pilot)	VTS
B1-01.07	Inform Agents of Tug Boat requirements	VTS
B1-01.08	Inform Pilot Cutter and at 2 hours before ETA	VTS
B1-01.09	Inform berths and at 2 hours before ETA	VTS
B1-01.10	Inform Mooring Service	VTS
B1-01.11	Check under which certificate is PEC vessel sailing	VTS
<b>B1-02</b>	<b>Establish tidal restrictions for vessel draught and air draught</b>	<b>HM</b>
B1-02.01	Obtain vessel draft and other characteristics	VTS
B1-02.02	Obtain air draught in order to ascertain bridge clearance for all vessels bound above bridge	VTS
B1-02.03	Obtain air draught in order to ascertain power cable clearance for all vessels bound under	VTS
B1-02.04	Check tides and draughts for deep draughted vessels	VTS
B1-02.05	Check tides and transit times for all vessels passing under bridges	VTS
B1-02.06	Obtain and manage schedule for vessels to avoid conflict with ETA/ETD	VTS
B1-02.07	Monitor tidal height against prediction	VTS

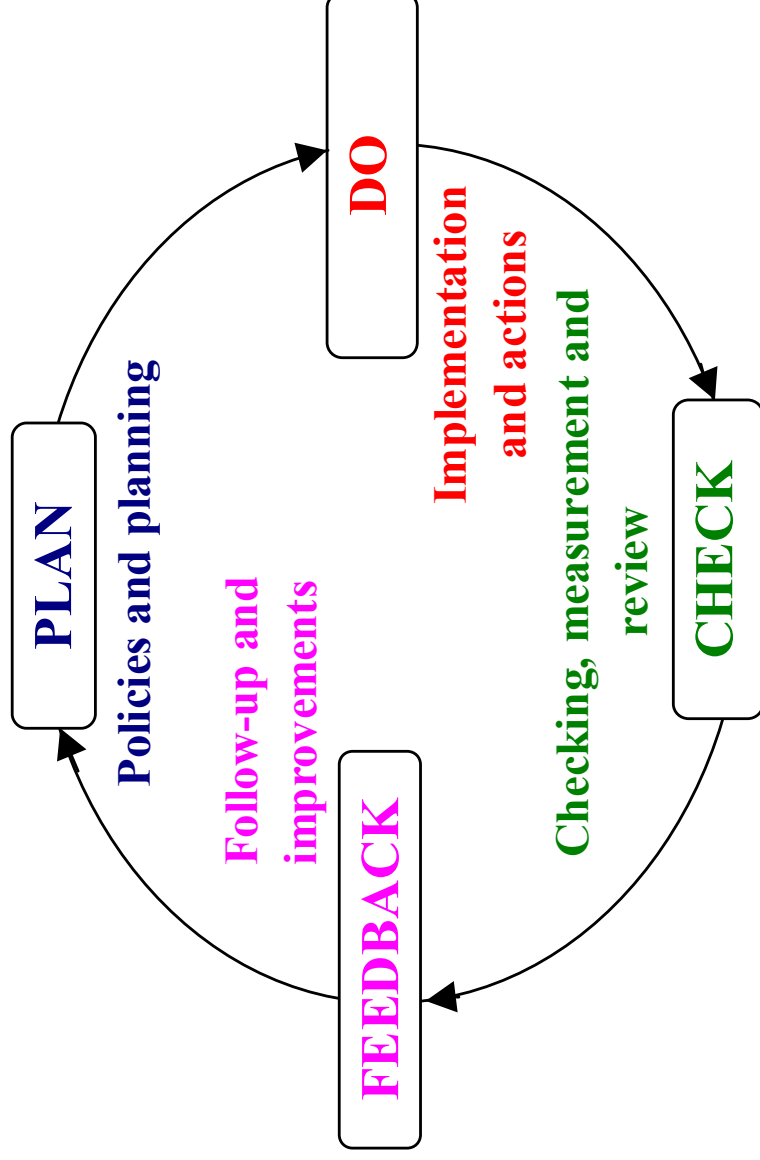
# Activities and Tasks

No.	Activities / Tasks	Post Indicator
<b>B2-04</b>	<b>Assessing standards on piloted vessel</b>	<b>HM</b>
B2-04.01	Evaluate by inspection suitability of ladder and boarding facilities before boarding	Pilot
B2-04.02	Evaluate navigational standards of vessel	Pilot
B2-04.03	Evaluate standards of vessel and crew	Pilot
B2-04.04	Report adverse results of evaluation to Port Control	Pilot
<b>B2-05</b>	<b>Co-operating with the bridge team and functioning within it</b>	<b>HM</b>
B2-05.01	Establish communication with Bridge Team and chain of command	Pilot
B2-05.02	Conduct Pilot-Master-Bridge Team information exchange	Pilot
B2-05.03	Read Pilot Card	Pilot
B2-05.04	Check vessel defect report	Pilot
B2-05.05	Agree Passage Plan with Master	Pilot
B2-05.06	Evaluate Bridge Team capabilities and effectiveness	Pilot
B2-05.07	Take charge of navigation and provide navigational advice to Master	Pilot
<b>B2-06</b>	<b>External communications</b>	<b>HM</b>
B2-06.01	Set appropriate VHF channels for communication and ensure portable is fully charged	Pilot
B2-06.02	Establish communications with VTS	Pilot
B2-06.03	nu	Pilot
B2-06.04	Establish communications with Tugs	Pilot
B2-06.05	Establish communications with Foyboatmen	Pilot
B2-06.06	Communicate between ships in case of loss of VTS communication	P/M

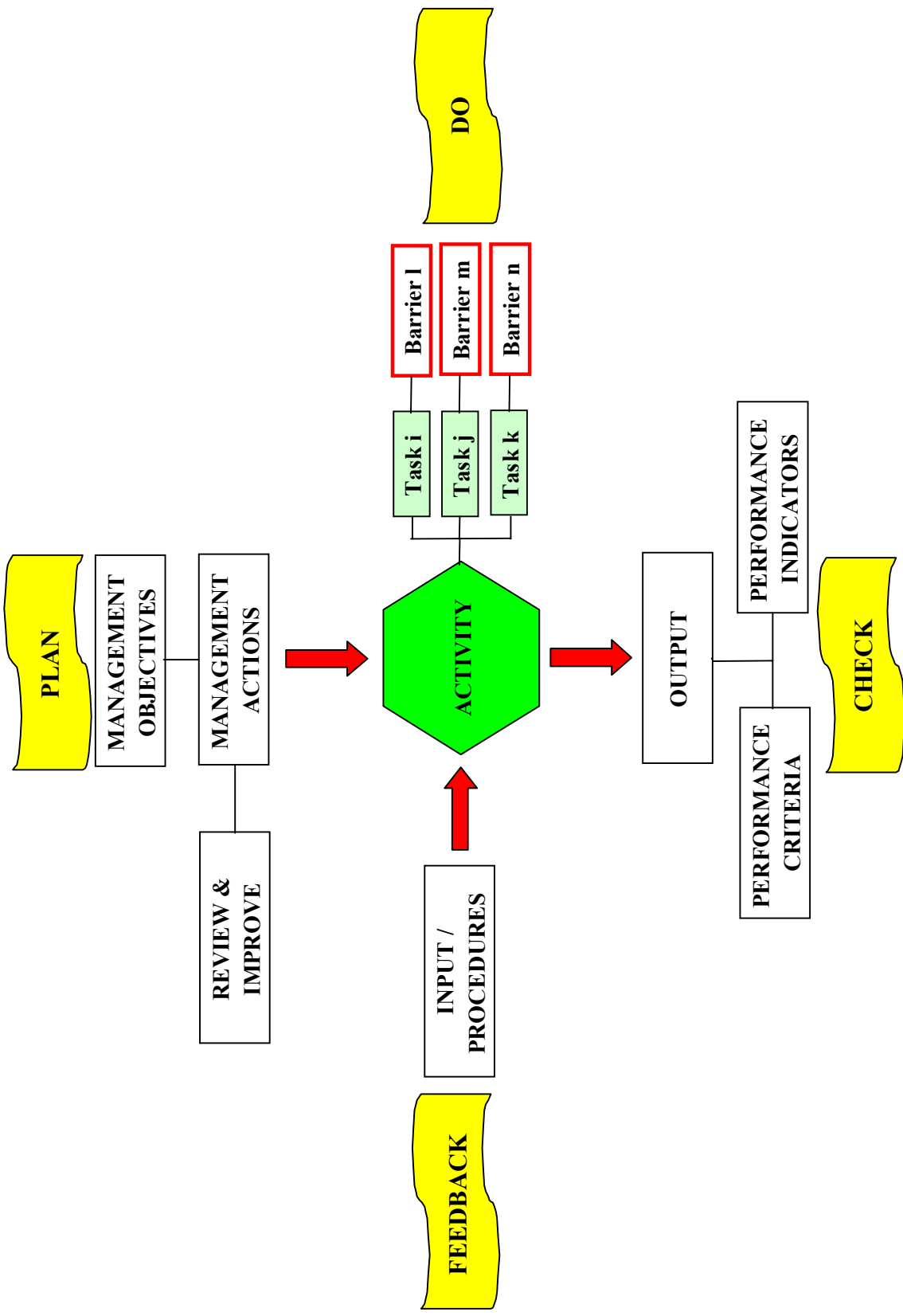
# Matching Tasks to Barriers



# The Essence of the SMS



# Safety Critical Activity (Link)





# Risk Evaluation and Assessment

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- Risk evaluation is carried out by establishing the likelihood and severity of consequences
- Risk assessment is carried out by comparing the evaluated risk against the risk acceptance criteria

# Risk = Likelihood \* Consequence

Consequences						Increasing Likelihood >					
People	Assets	Environment	Reputation			Not heard of in ports industry	Has occurred in ports industry	Has occurred in Port	Happens several times per year in ports industry	Happens several times per year in Port	Happens every day
						A	B	C	D	E	F
No injury	No damage	No damage	No impact	0		A0	B0	C0	D0	E0	F0
Slight injury	Slight damage	Slight effect	Slight impact	1		A1	B1	C1	D1	E1	F1
Minor injury	Minor damage	Minor effect	Limited impact	2		A2	B2	C2	D2	E2	F2
Major injury	Local damage	Localised effect	Considerable impact	3		A3	B3	C3	D3	E3	F3
Single fatality	Major damage	Major effect	National impact	4		A4	B4	C4	D4	E4	F4
Multiple fatalities	Total loss	Massive effect	International impact	5		A5	B5	C5	D5	E5	F5



# Risk Acceptance Criteria

## *Sanity Check*

Region	Criteria
<b>Tolerable or ALARP</b>	1 Requires a minimum of two effective barriers in place for all threats
	2 Requires a minimum of one effective recovery measure (barrier) for each identified consequence
	3 Requires a minimum of one effective control in place for all escalation escalation factors
<b>Intolerable</b>	1 Requires a minimum of three effective barriers in place for all threats
	2 Requires a minimum of two effective recovery measures (barriers) for each identified consequence
	3 Requires a minimum of one effective control in place for all escalation factors

## Some of the Findings

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- General uncertainty regarding vessel reliability and handling characteristics
- Difference between vessels' ISM Code and the port SMS
- Uncertainty regarding operational criteria
- Incomplete information exchange between the master and bridge team, master and pilot, etc.
- Imprecise reporting to VTS

## Some of the Findings

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- Monitoring role of VTS (as opposed to traffic control role)
- Uncertainty in the safety margin in UKC
- Uncertainty in vessel air draught
- Operating near the limits of the Passage Plan
- Uncertainties about control of small crafts
- Etc.

## Conclusions

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- Risk based methodologies applicable to the shipping industry are fairly well developed
- Shipping industry has been at the crossroads for some time
- Step change is needed for the goal-setting approach to safety
- Application of modern risk management techniques brings benefits and can be demonstrated to other stakeholders, customers, insurers, general public, etc.

**Thank you for your patience**



**Risk Support**