

BowTie methodology &

◀BowTieXP



What is our focus?

4

Research
Building concepts



5

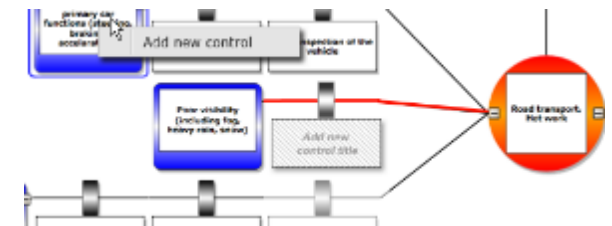
Standard tools
Industry leading



3

6

Capturing industry expertise



7

Training
Consultancy





1500+ customers in 12 industries

Customer list

A.P. Moller Maersk - Drilling
A.P. Moller Maersk - Oil & Gas
A.P. Moller Maersk - Supply Service
A.P. Moller Maersk - Svitzer
Acom do Brasil
Abu Dhabi Gas
Accident Investigation
Acergy Australia
Acona
ADM Europe
Advantica
Aera Energy
Aerial Survey
AET Tankers
Agder Energi Nett AS
Agip Kazakhstan
Air New Zealand
Air Service Gabon
Airborne Energy Solutions
AirTanker Services
Akzo Nobel
Al Furat Petroleum Company
Al Hoon Gas
Alberta Environment
Alberta Oilsands
Allseas Engineering
Alyeska Pipeline Service
AMC
Amec Group
American Airlines
ANP
Apache Energy
Applus RTD
Arcadis UK
Arch Chemicals
A-RisC
Asset Rail
Atco I-Tek
Atkins Defence Systems
Atlantic Marine Services
Atwood Oceanics
Australian Defence Force
Autoridade Nacional do Petroleo
Avebe
Avinor
Baker Hughes
BAM Rail

Dalma Energy & Co.
D'Appolonia
DC Groep
De Nederlandsche Bank
Defensie Pijpleiding O
Delmar Systems
Delta
Depart. of Sust. & Env
Dgac
Diamond Offshore
Dienst Infrastructuur e
Dockwise Shipping
Doddal Engineering
Dolphin Geophysical
Domaco Milieumanag
Dong E&P
Doris Engineering
Dyka
Easter Finance Nederland
ECN
Egyptian Drilling Compan
Elpita
Emirates Airline
Energy Resources Consv.
Enesco
Engen Petroleum
Enasco Australia
Ensinger International Energ
E-ON
Era Helicopters
Erasmus Medisch Centrur
ESR Technology
EXCO Resources
EXPRO
Fabricom GTI
Fahud Oilfield Services
Falcon Oilfield Services
Federal Reserve Board
Finnair
Finncomm Airlines
Flair Airlines
Fluor Corporation
Food and Drug Administr
Fortescue Metals Group
Fugro
G.O.G. Energy Resources
Gasco

LyondellBasell
MACCS Group
May Gurney

Scandpower
Schiphol
Schlumberger



National Australia Bank
Shell - Real Estate



Uman Air
Oman LNG

IAQA
TATA Steel International

CORE-IRM
Covra

Kuwait Oil Company
Labrador Petro-Management

Royal Australian Air Force
Royal Caribbean Cruises

WorleyParsons
Xstrata Copper

CORE-IRM
Covra

Kuwait Oil Company
Labrador Petro-Management

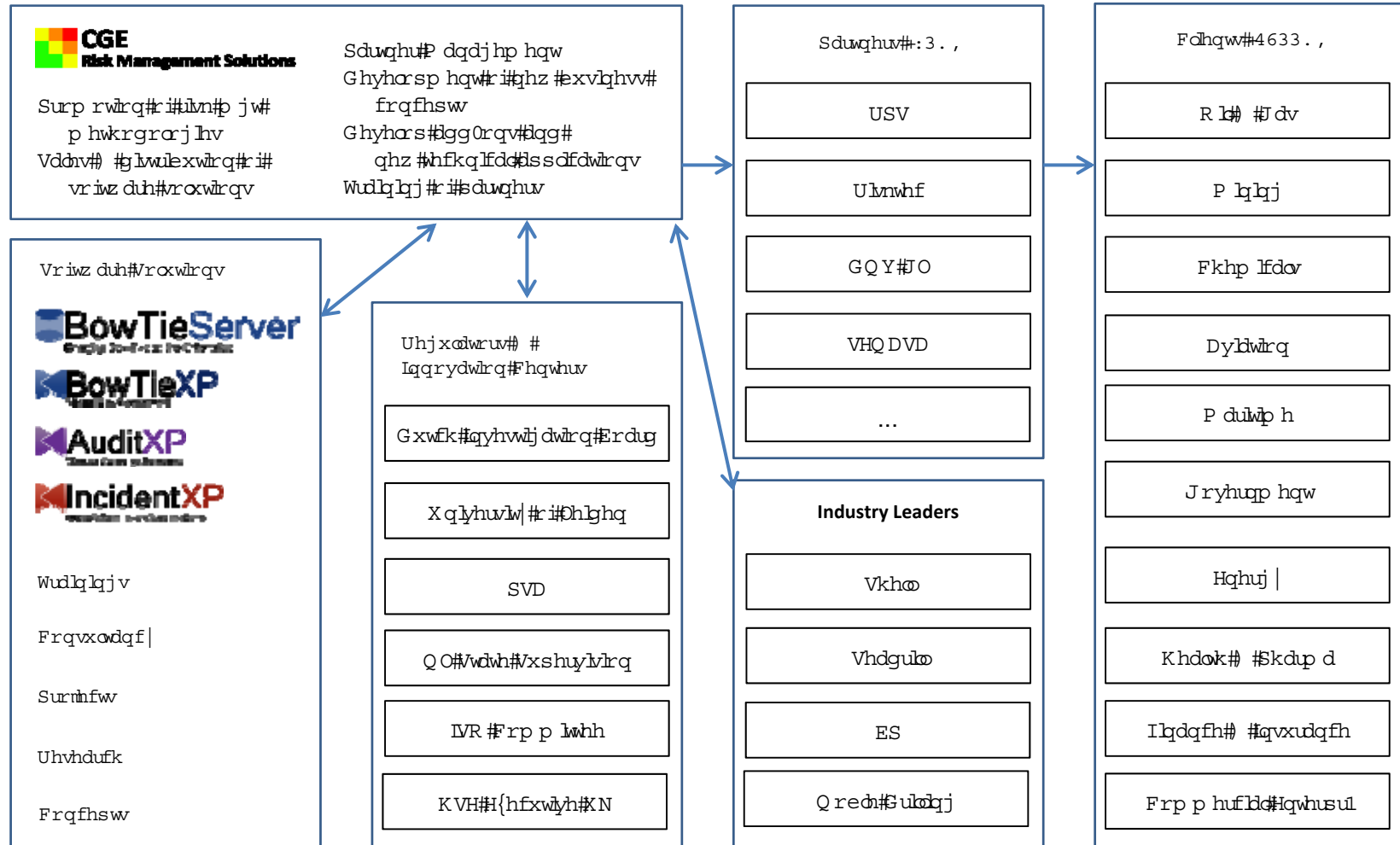
Royal Australian Air Force
Royal Caribbean Cruises

WorleyParsons
Xstrata Copper

BAM Rail
Barrick Gold
Basell Polyolefine
BC Hydro
Belfast City Airport
Belgium Defence
BG Group
BHP Billiton Diamonds
BHP Billiton Iron Ore
BHP Billiton Olympic Dam
BHP Billiton Petroleum
BHP Illawarra Coal
Bijzet Aircraft & Helicopters
Blade Offshore Services
Bluewater Energy Services
BMT Isis
Boots & Coots
Borouge
Garco
GBF Underground Mining
GDF Production Nederland
GE Healthcare
GeoTechninvest
Germanischer Lloyd Industr. Serv.
GS Caltex Corporation
Gulf Drilling International
HaGa Ziekenhuis
Halliburton ESG
Harrods Aviation
Haskoning Nederland
Heathgate Resources
Helix Well Ops
Hellenic Petroleum
Hertel Holding
Hess
Hong Kong CAD
Oman LNG
OMV E&P
OMV Refining & Marketing
Onderzoeksraad voor de veiligheid
Optare Ventures
Organik Kimya Netherlands
Oxand Risk & Asset Management
P&O Maritime Services
Paradigm Digital
Parker Drilling Netherlands
Pecten Cameroon
Peinemann Kranen
Perth Airport
Petra Resources
Petrofac International
Petrotrin
Petroleum Development Oman
Petroleum Safety Authority
TATA Steel International
Technip
Teijin Aramid
Thai Industrial Gases
The Main School of Fire Service
The Nigeria Liquefied Natural Gas
The Oil and Pipelines Agency
Total
Transocean
Trinidad Drilling
Tronox Pigments
TS Marine Pty
TU Delft - TNW
Tulane University
Tullow Oil
UK P&I Club
UMCG Ambulanceorg
Gasco
GBF Underground Mining
GDF Production Nederland
GE Healthcare
GeoTechninvest
Germanischer Lloyd Industr. Serv.
GS Caltex Corporation
Gulf Drilling International
HaGa Ziekenhuis
Halliburton ESG
Harrods Aviation
Haskoning Nederland
Heathgate Resources
Helix Well Ops
Hellenic Petroleum
Hertel Holding
Hess
Hong Kong CAD
Oman LNG
OMV E&P
OMV Refining & Marketing
Onderzoeksraad voor de veiligheid
Optare Ventures
Organik Kimya Netherlands
Oxand Risk & Asset Management
P&O Maritime Services
Paradigm Digital
Parker Drilling Netherlands
Pecten Cameroon
Peinemann Kranen
Perth Airport
Petra Resources
Petrofac International
Petrotrin
Petroleum Development Oman
Petroleum Safety Authority
TATA Steel International
Technip
Teijin Aramid
Thai Industrial Gases
The Main School of Fire Service
The Nigeria Liquefied Natural Gas
The Oil and Pipelines Agency
Total
Transocean
Trinidad Drilling
Tronox Pigments
TS Marine Pty
TU Delft - TNW
Tulane University
Tullow Oil
UK P&I Club
UMCG Ambulanceorg
Petrone
Petronas
University of Amsterdam
PGS Geophysical
PH Helicopters
Phoenix Park Gas Processors
Powerlink Queensland
Precision Energy Services
Prinses Amalia Windpark
ProRail
Prosafe Offshore
PT Angkasa Pura II
Pt Geoservices - BNI Indonesia
PTT E & P
PTTEP Australia
Qatar Gas
Qatar Petrochemical
Qatar Petroleum
Qatar Shell Service Company
Queensland Rail
RAF Valley, Ministry of Defence
RAPL Nederland
RBA Limited
Reg. Ambulance Dienst Utrecht
Repsol YPF
Reym
Rig Inspection Services
Rijkswaterstaat
Rio Tinto Alcan
Rowan Companies
Royal Australian Air Force
Royal Caribbean Cruises
WorleyParsons
Xstrata Copper

-  Afriqiyah Airways
-  Air New Zealand
-  Air France
-  Airways New Zealand
-  Air Service Gabon
-  AirTanker Services Limited
-  American Airlines
-  Amsterdam Schiphol Airport
-  ArkeFly
-  Ascent Flight Training
-  Avinor
-  Belfast City Airport
-  Bizjet Aircraft and Helicopters Management
-  Boeing Defense UK
-  Bristow Helicopter
-  Britair France
-  British Airways
-  Canadian Base Operators
-  Civil Aviation Authority UK
-  Civil Aviation Authority Singapore
-  CASA - Civil Aviation Safety Authority
-  CHC Helicopter
-  Christchurch International Airport
-  Civil Aviation Authority UK
-  Corendon Dutch Airlines
-  DGAC
-  ERA Helicopters
-  FAA
-  Finnair
-  Finnish Commuter Airlines
-  Flair Air
-  Flight Safety Foundation
-  Freebird Airlines
-  Hong Kong Civil Aviation Department
-  HOP Brit Air
-  Italfly
-  Irish Aviation Authority
-  Japan Airlines
-  Jayrow Helicopters
-  Jazeera Airways
-  JetStar
-  Kelowna Flightcraft
-  KLM Royal Dutch Airlines
-  KLM UK
-  London City Airport
-  Malaysian Airlines
-  Manchester Airport
-  MHS Aviation
-  Military Aviation Authority UK
-  Nayak Aircraft Services
-  Noordzee Helikopters Vlaanderen
-  Norwegian Air
-  Norwich Airport
-  Oman Air
-  Pegasus Airlines
-  Qantas
-  Royal Australian Air Force Australia
-  Royal Air Force UK
-  Royal Netherlands Aeronautical Association
- Ryanair
- SFS Aviation
- Singapore Air Transport Training College
-  Shell Aircraft International
-  Skyline Helicopters
-  SkyWest Airlines
-  SmartLynx Airlines
-  Turkish Airlines
-  UK Air Accident Investigation Board
-  Vancouver Island Helicopters

How do we operate?



What is...
Examples of...
Why...
BowTie in steps
Set of bowties,
now what?

BowTie methodology



What is Bowtie risk assessment?

Bowtie history



THE UNIVERSITY
OF QUEENSLAND
AUSTRALIA

1979



1988



90's

 **BowTieXP**
The next generation bow-tie methodology tool

00's



Bowtie today



-  Oil & Gas
-  Chemical
-  Energy
-  Mining
-  Aviation
-  Rail transport
-  Maritime
-  Construction
-  Medical
-  Financial
-  Government
-  IT

-  Afriqiyah Airways
-  Air New Zealand
-  Air France
-  Airways New Zealand
-  Air Service Gabon
-  AirTanker Services Limited
-  American Airlines
-  Amsterdam Schiphol Airport
-  ArkeFly
-  Ascent Flight Training
-  Avinor
-  Belfast City Airport
-  Bizjet Aircraft and Helicopters Management
-  Boeing Defense UK
-  Bristow Helicopter
-  Britair France
-  British Airways
-  Canadian Base Operators
-  **Civil Aviation Authority UK**
-  **Civil Aviation Authority Singapore**
-  **CASA - Civil Aviation Safety Authority**
-  CHC Helicopter
-  Christchurch International Airport
-  Civil Aviation Authority UK
-  Corendon Dutch Airlines
-  **DGAC**
-  ERA Helicopters
-  **FAA**

-  Finnair
-  Finnish Commuter Airlines
-  Flair Air
-  Flight Safety Foundation
-  Freebird Airlines
-  **Hong Kong Civil Aviation Department**
-  HOP Brit Air
-  Italfly
-  **Irish Aviation Authority**
-  Japan Airlines
-  Jayrow Helicopters
-  Jazeera Airways
-  JetStar
-  Kelowna Flightcraft
-  KLM Royal Dutch Airlines
-  KLM UK
-  London City Airport
-  Malaysian Airlines
-  Manchester Airport
-  MHS Aviation
-  **Military Aviation Authority UK**
-  Nayak Aircraft Services
-  Noordzee Helikopters Vlaanderen
-  Norwegian Air
-  Norwich Airport
-  Oman Air
-  Pegasus Airlines
-  Qantas
-  Royal Australian Air Force Australia
-  Royal Air Force UK
-  Royal Netherlands Aeronautical Association
- Ryanair
- SFS Aviation
- Singapore Air Transport Training College

-  Shell Aircraft International
-  Skyline Helicopters
-  SkyWest Airlines
-  SmartLynx Airlines
-  Turkish Airlines
-  **UK Air Accident Investigation Board**
-  Vancouver Island Helicopters

Currently
evaluating:

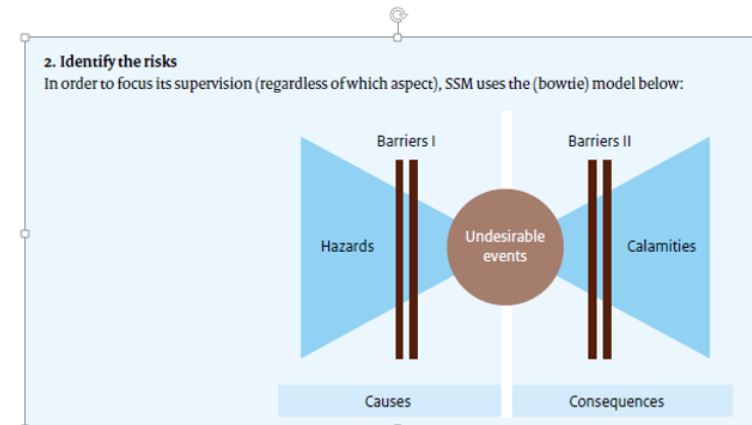
CAA Austria
CAA Norway
CAA Poland
CAA Italy
CAA Peru
EASA
GCAA

Frrshudwlrq#z lkw#hj xodwru

3 questions:

- Do we understand what can go wrong?
- Do we know what our systems are to prevent this from happening?
- Do we have information to assure us they are working effectively?

Oil & Gas Regulators: State Supervision of the Mines (NL)

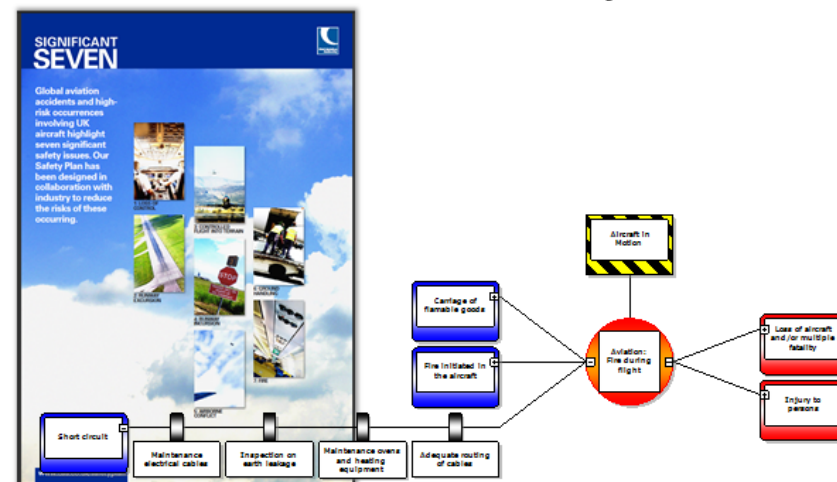


Oil & Gas Regulators: Petroleum Safety Authority (NO)

The screenshot shows the PSA website with several callouts highlighting key points:

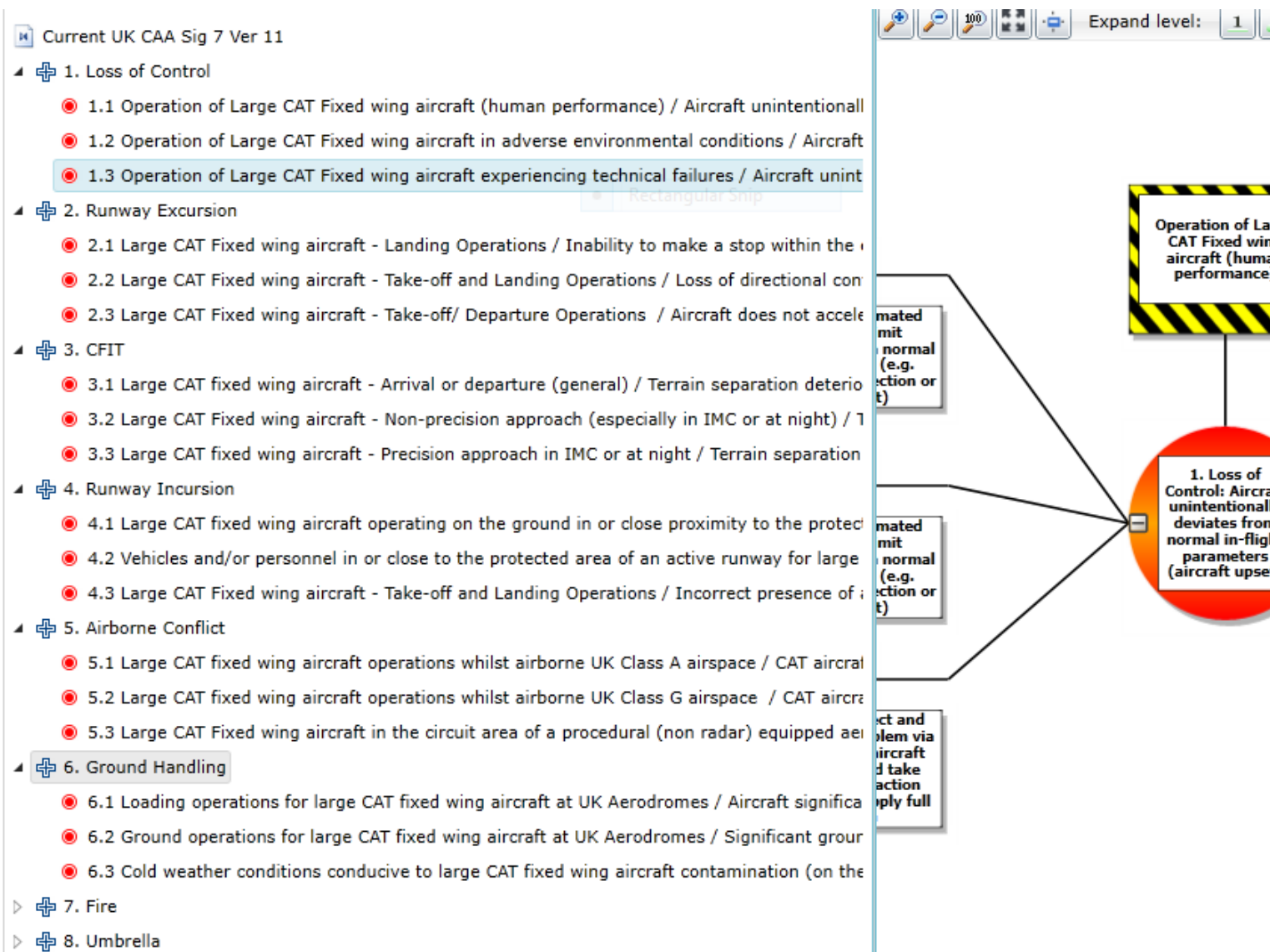
- Failure or weakening of barriers is often a cause of undesirable incidents in the petroleum sector.** (Callout pointing to the 'BARRIERS' section)
- The industry must: ensure robust technical, operational and organisational barriers. This is crucial for preventing accidents and reducing risk.** (Callout pointing to the 'The industry must' section)
- To identify and give weight to operational, organisational and technical barrier elements and their role in the risk picture.** (Callout pointing to the 'The PSA will' section)

Aviation Regulators: Civil Aviation Authority (UK)

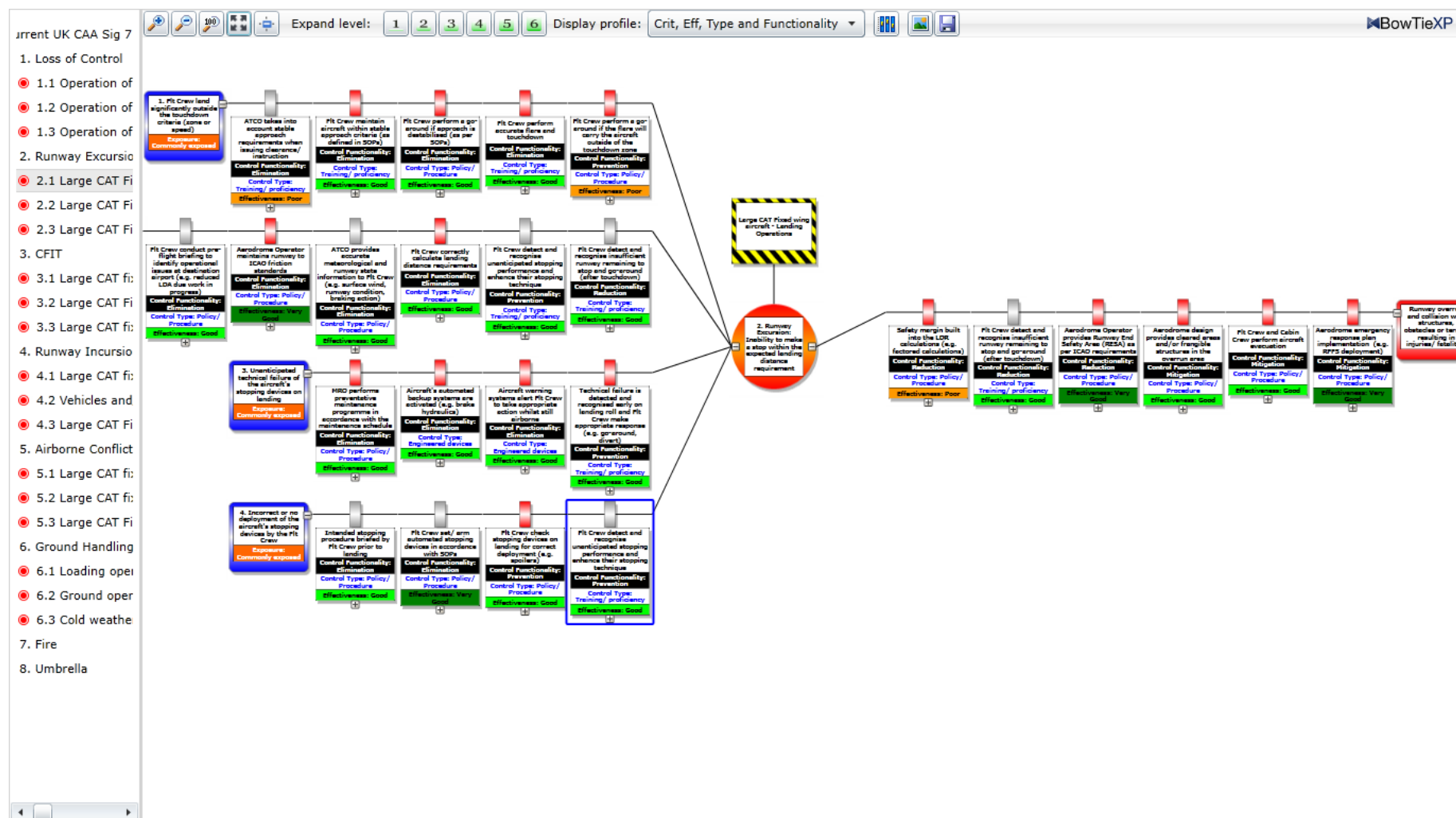


Performance based regulation means developing a comprehensive risk picture with the organisations we regulate and building our knowledge and data to make sure we target our regulation in the areas where it will make the biggest difference.

CAA UK Significant Seven

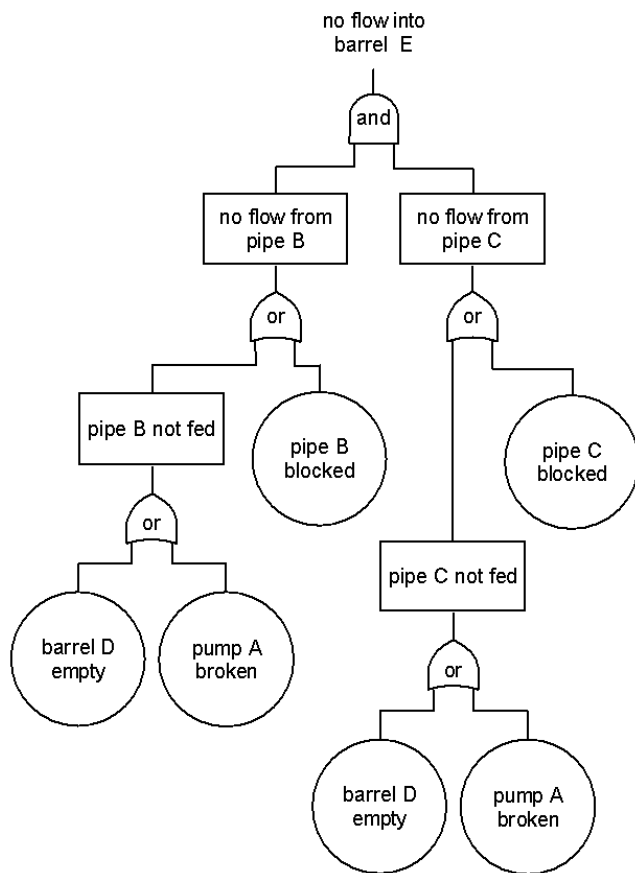


CAA UK Significant Seven

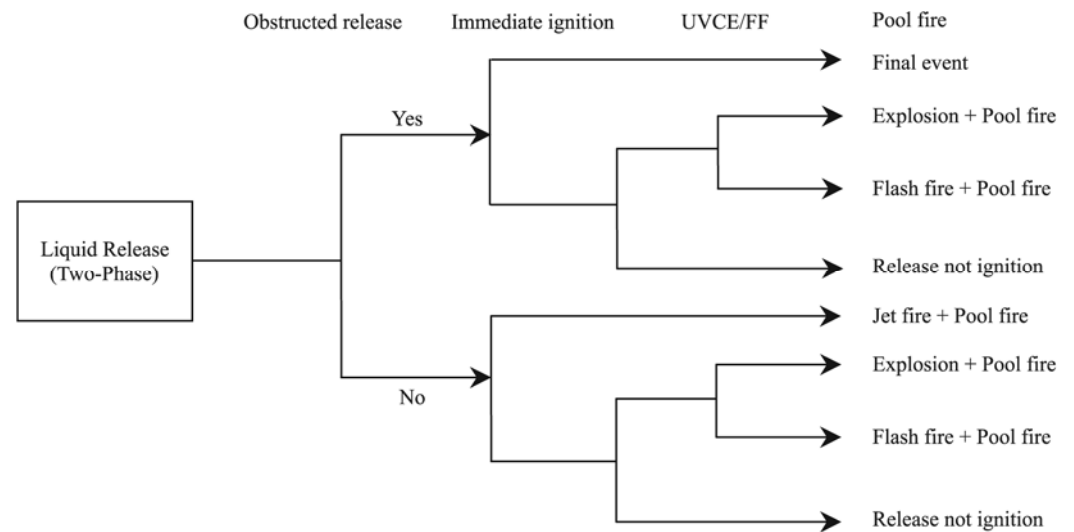


Bowtie's parents

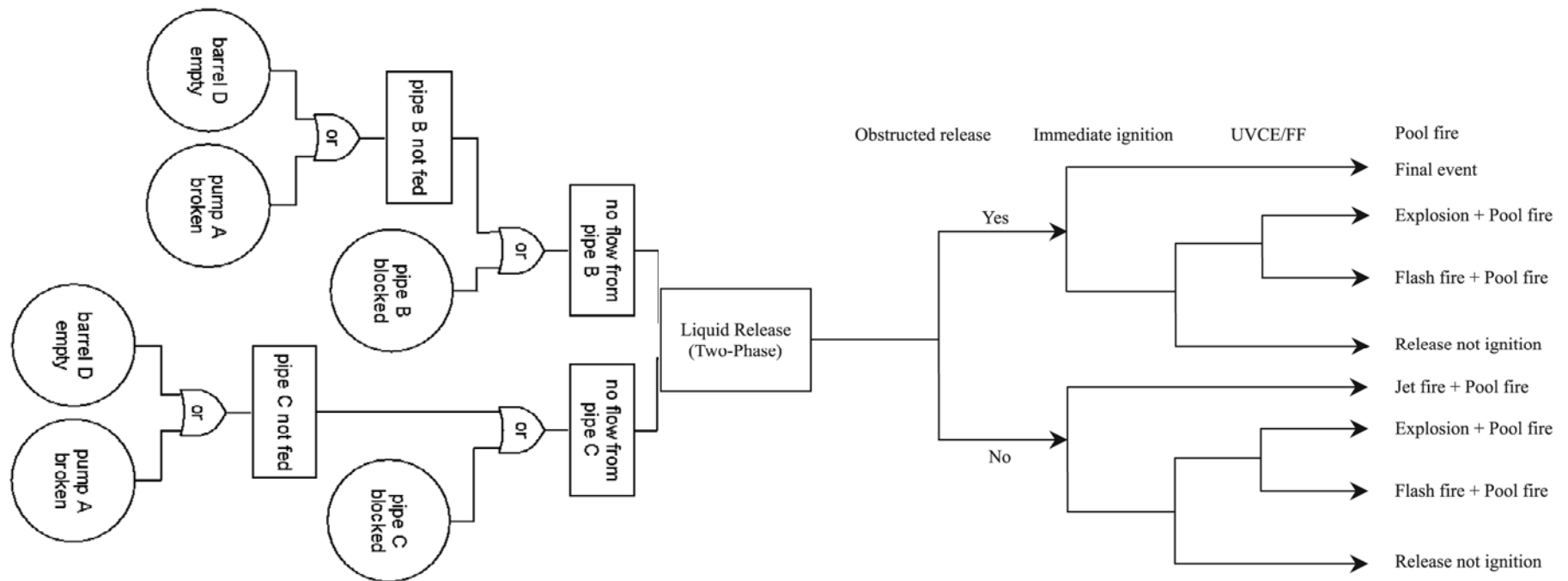
Fault tree

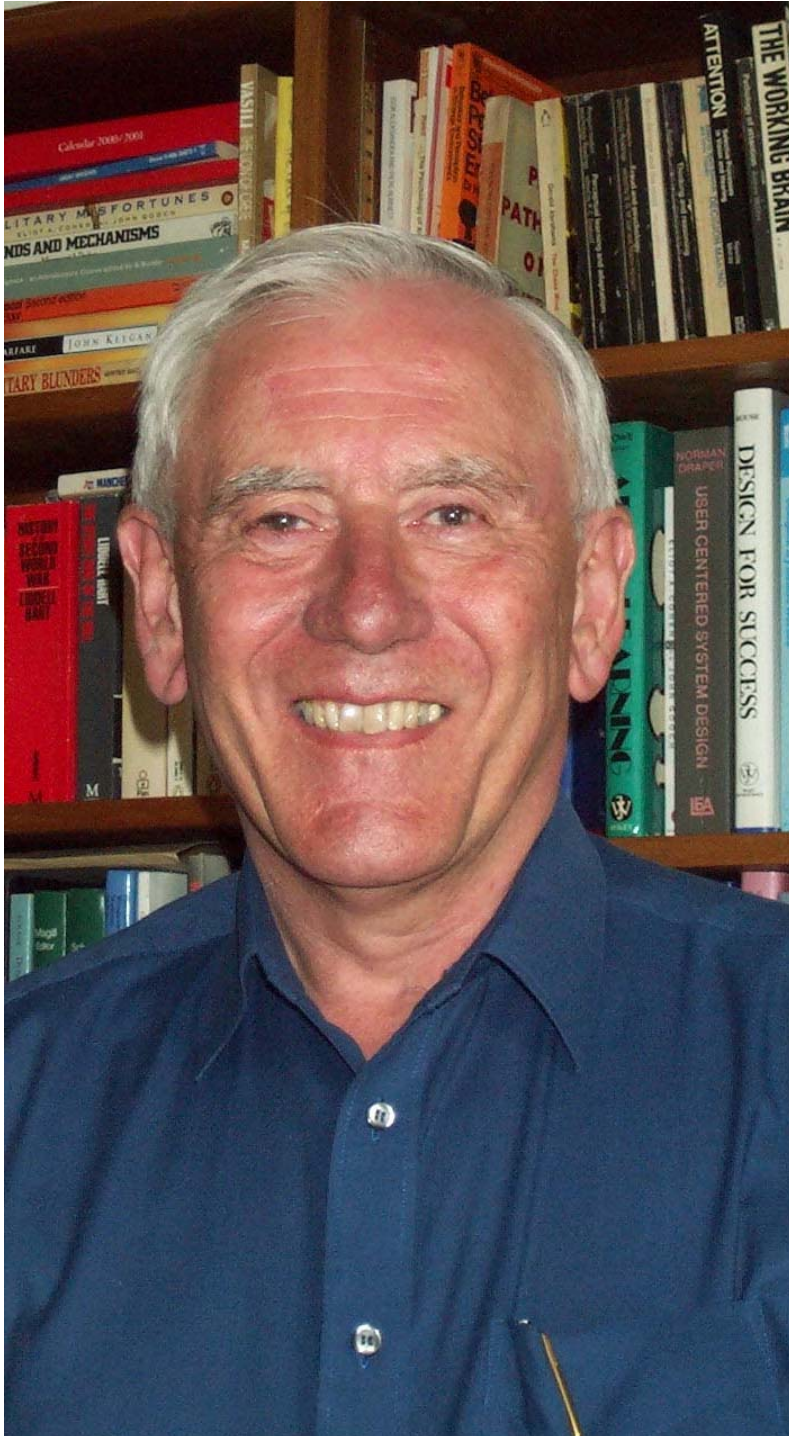


Event tree

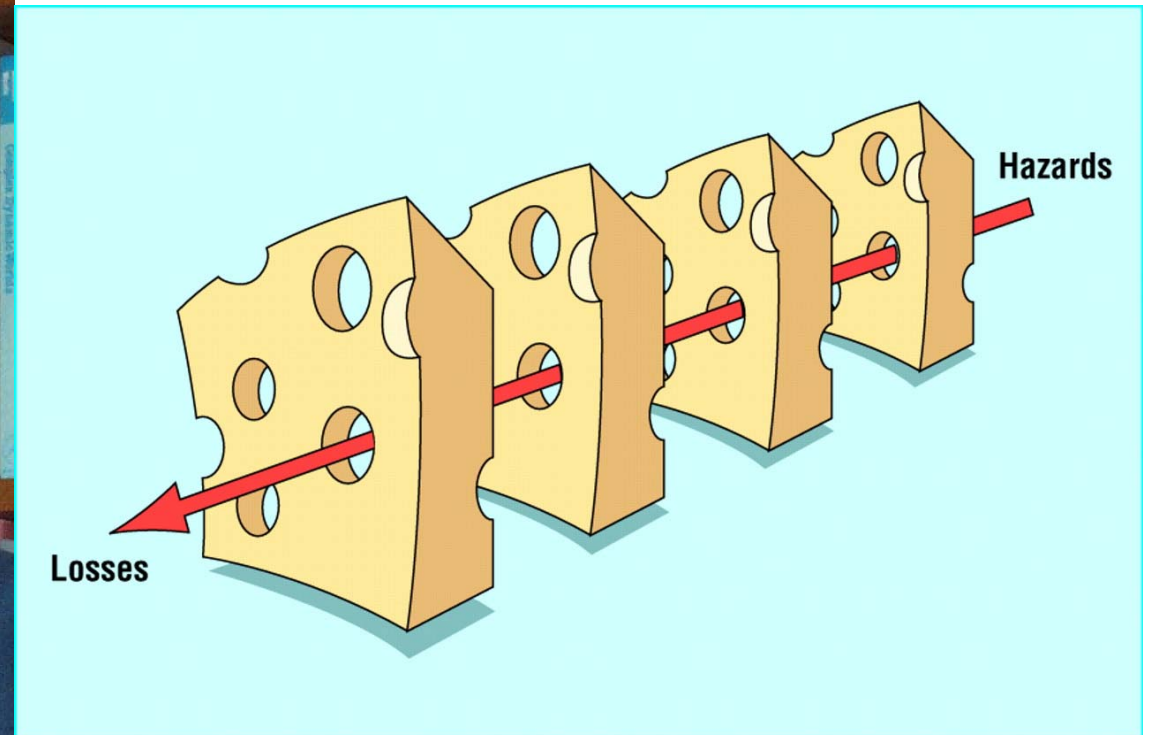


Connect them

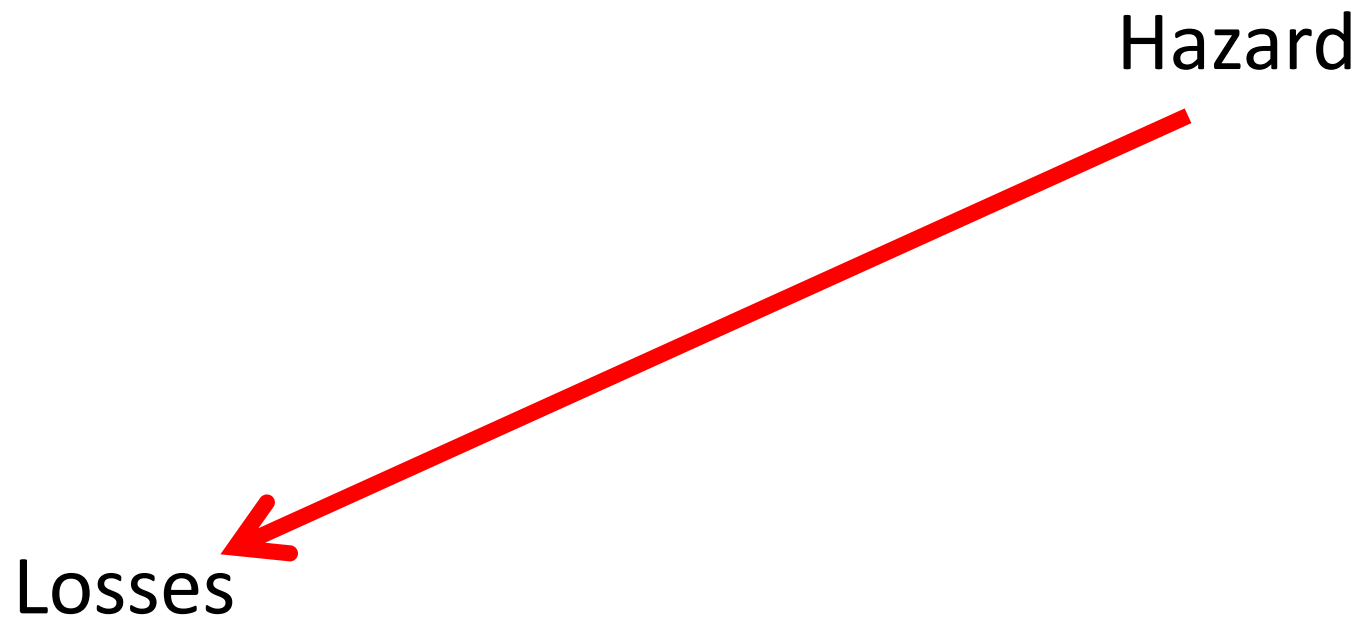




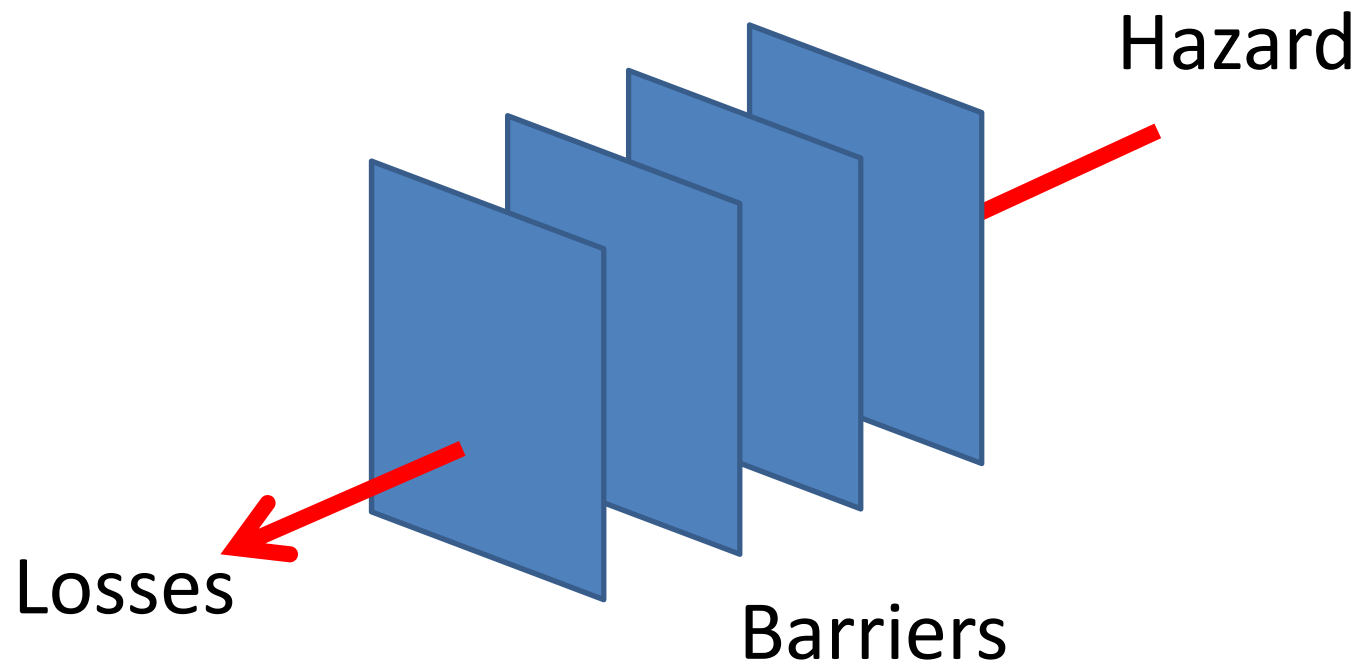
Barrier thinking



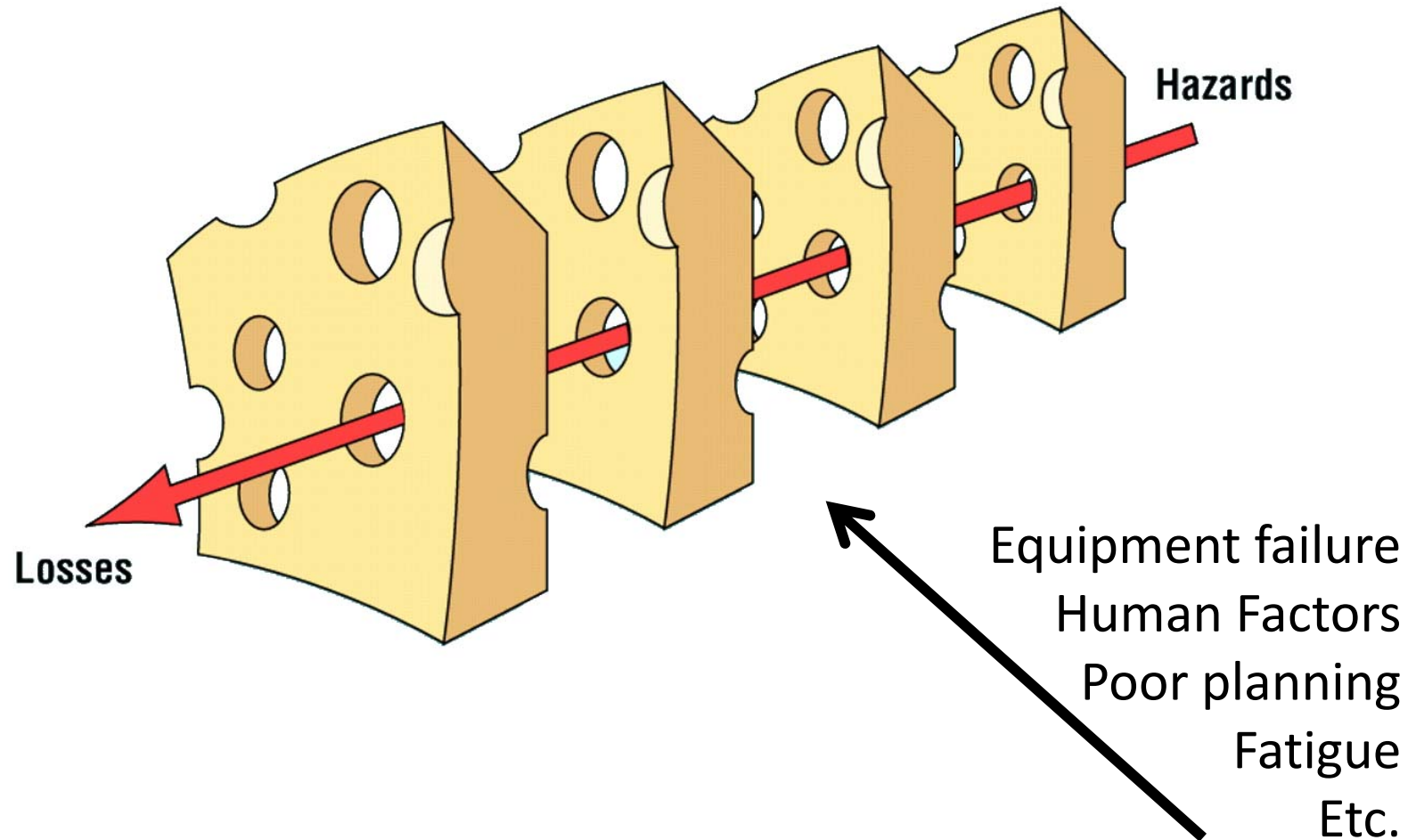
Barrier thinking



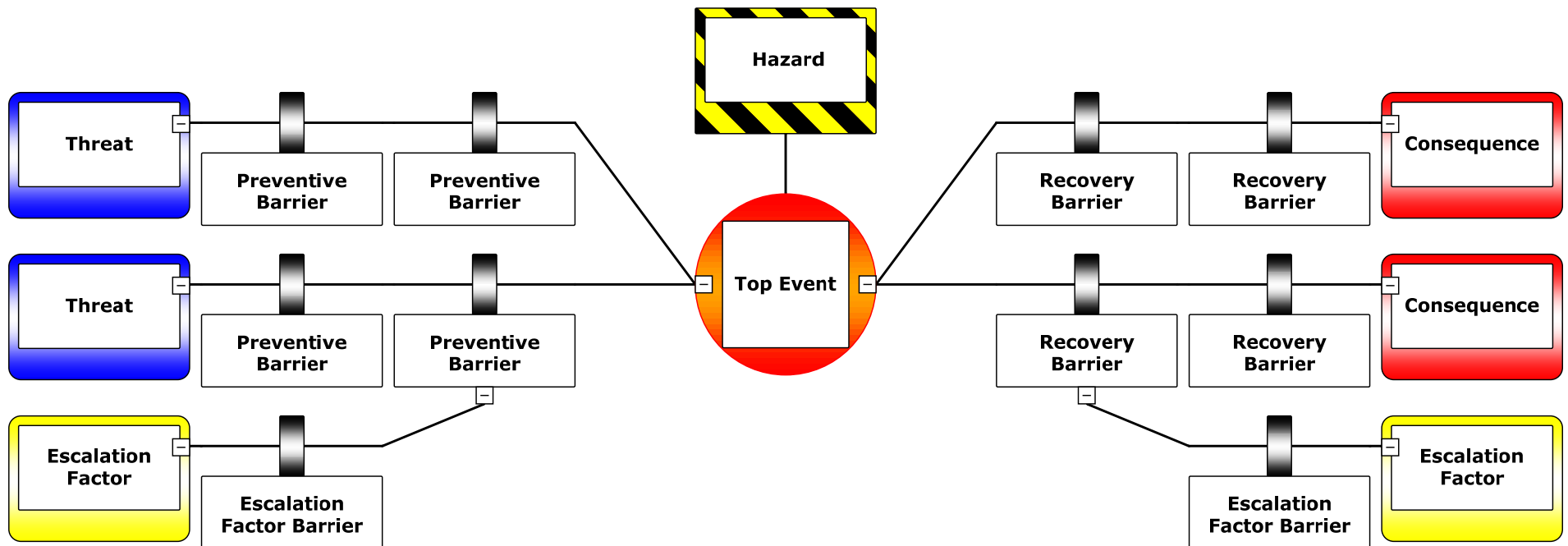
Barrier thinking



Barrier thinking



Communicative version

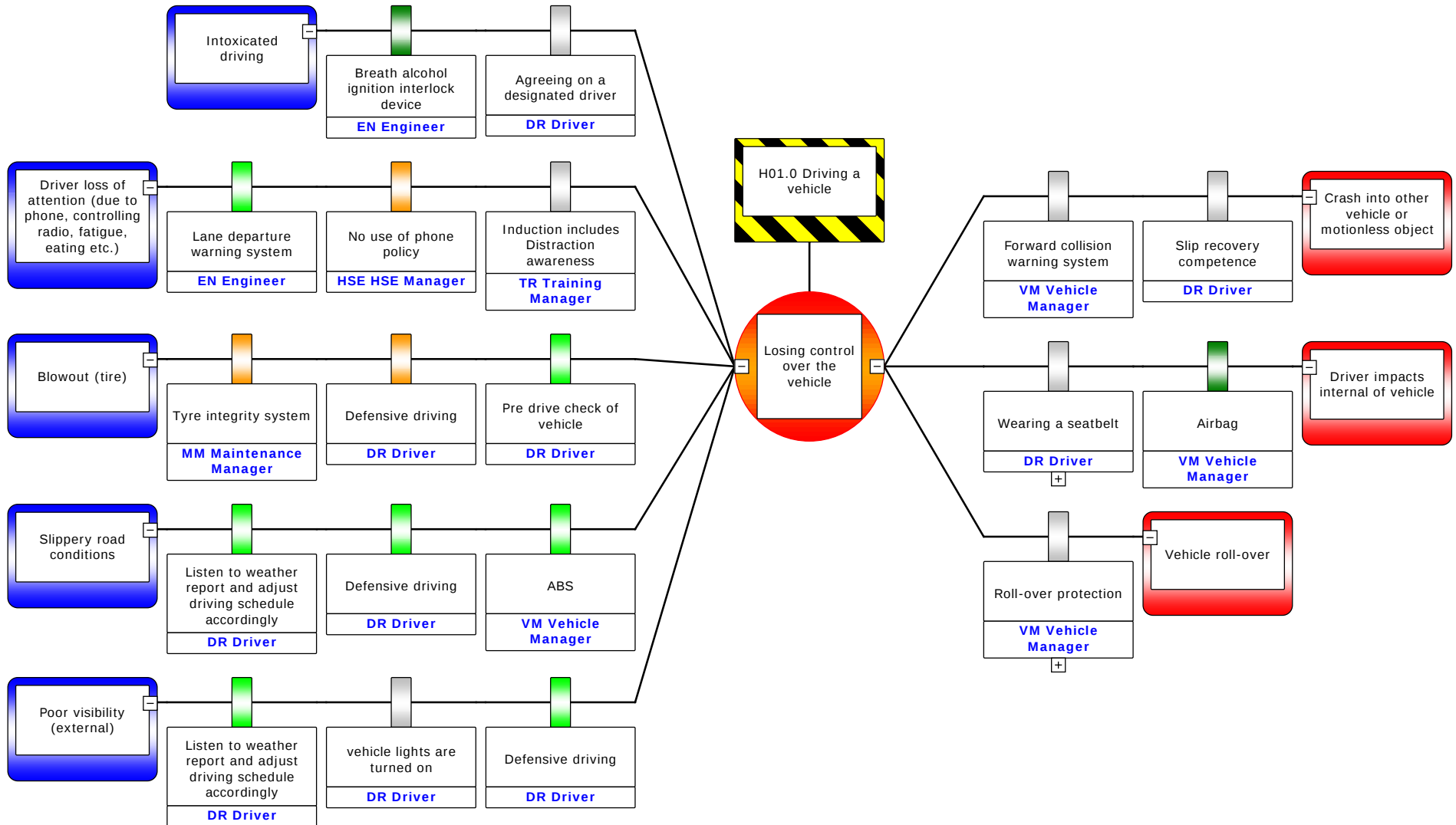


“Safety barriers are physical and/or non-physical means planned to prevent, control, or mitigate undesired events or accidents.”

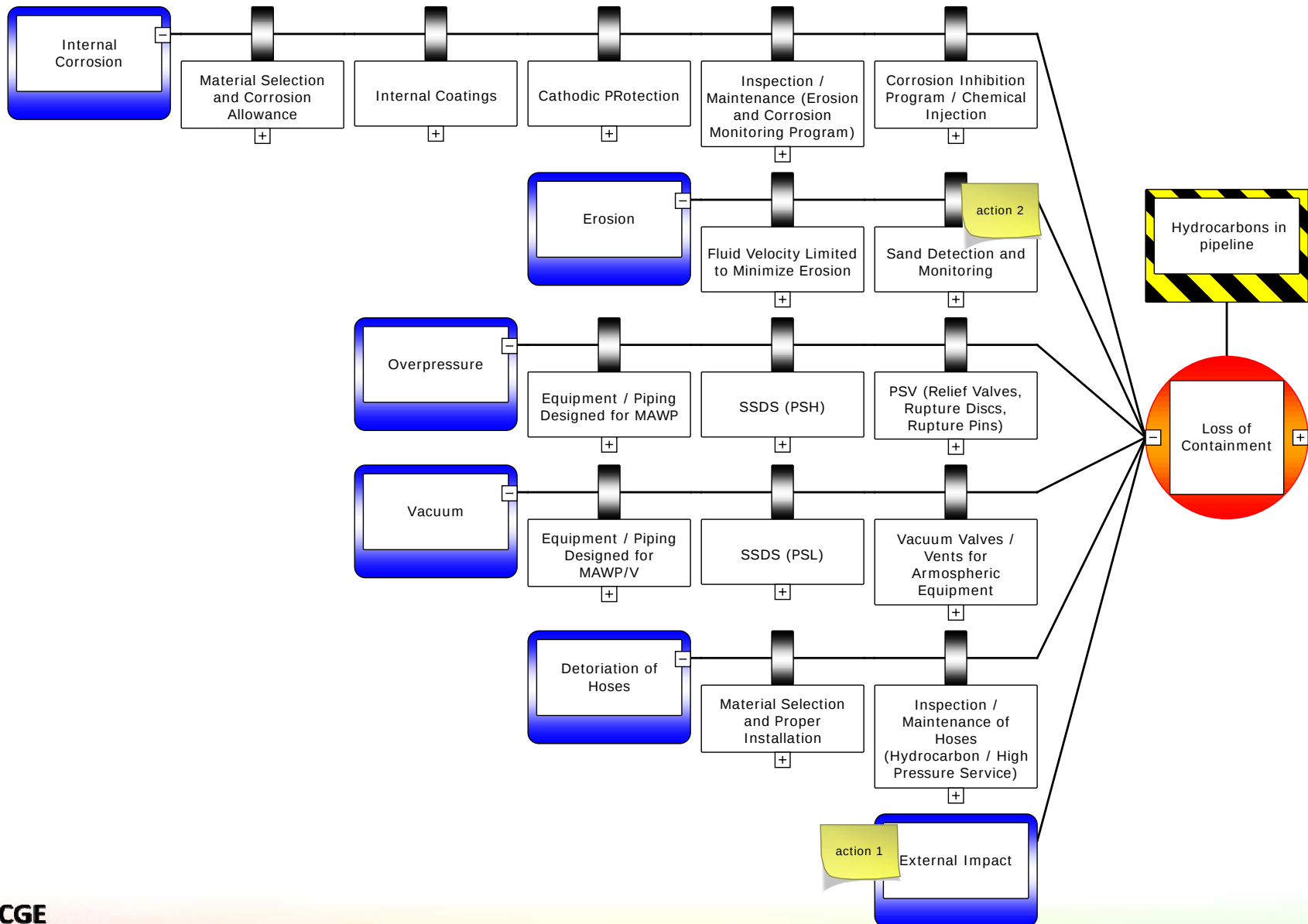
Snorre Sklet (2006). Safety barriers: Definition, classification, and performance. *Journal of Loss Prevention in the Process Industries*, 19(5):494–506

Examples of Bowtie risk assessment

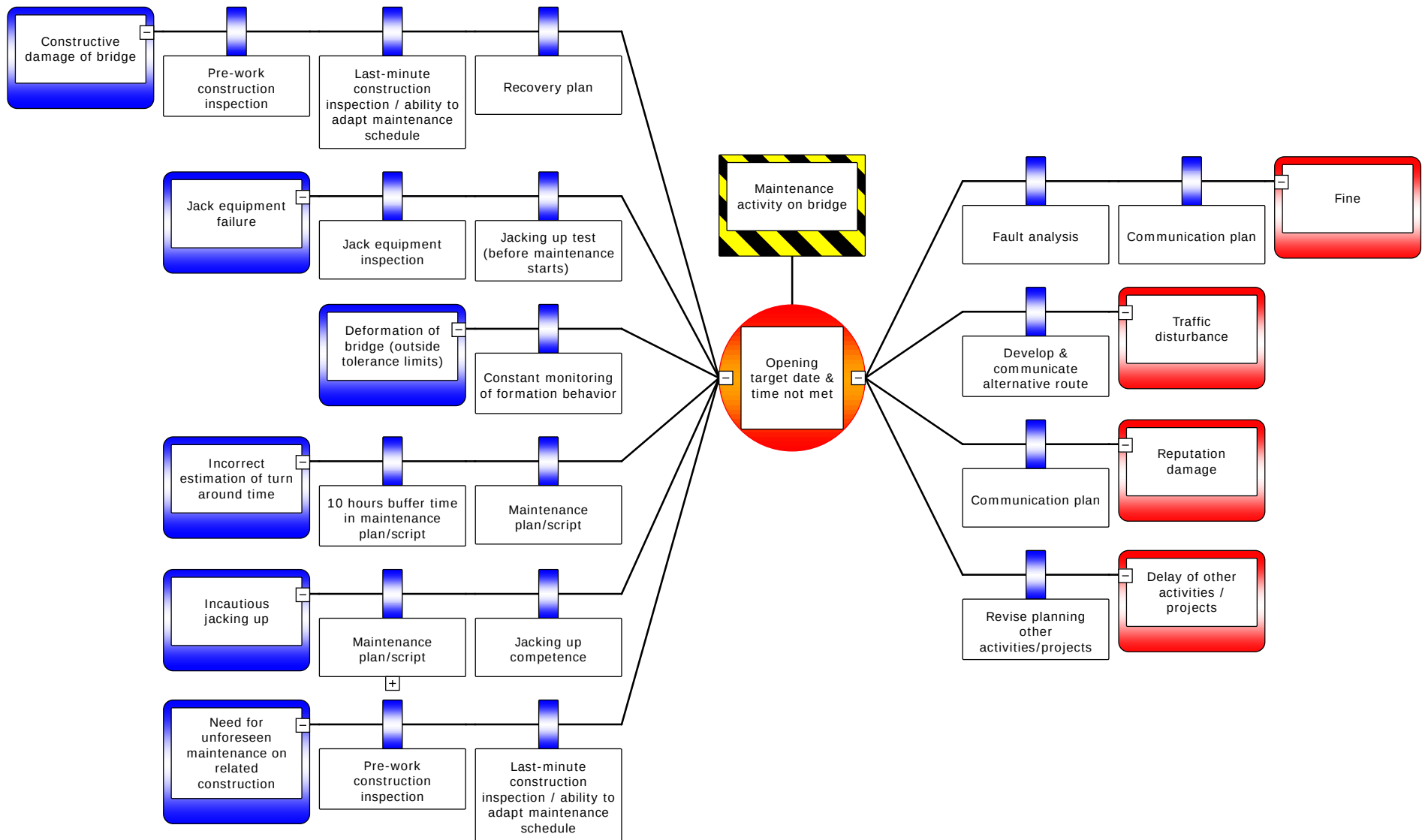
Road transport



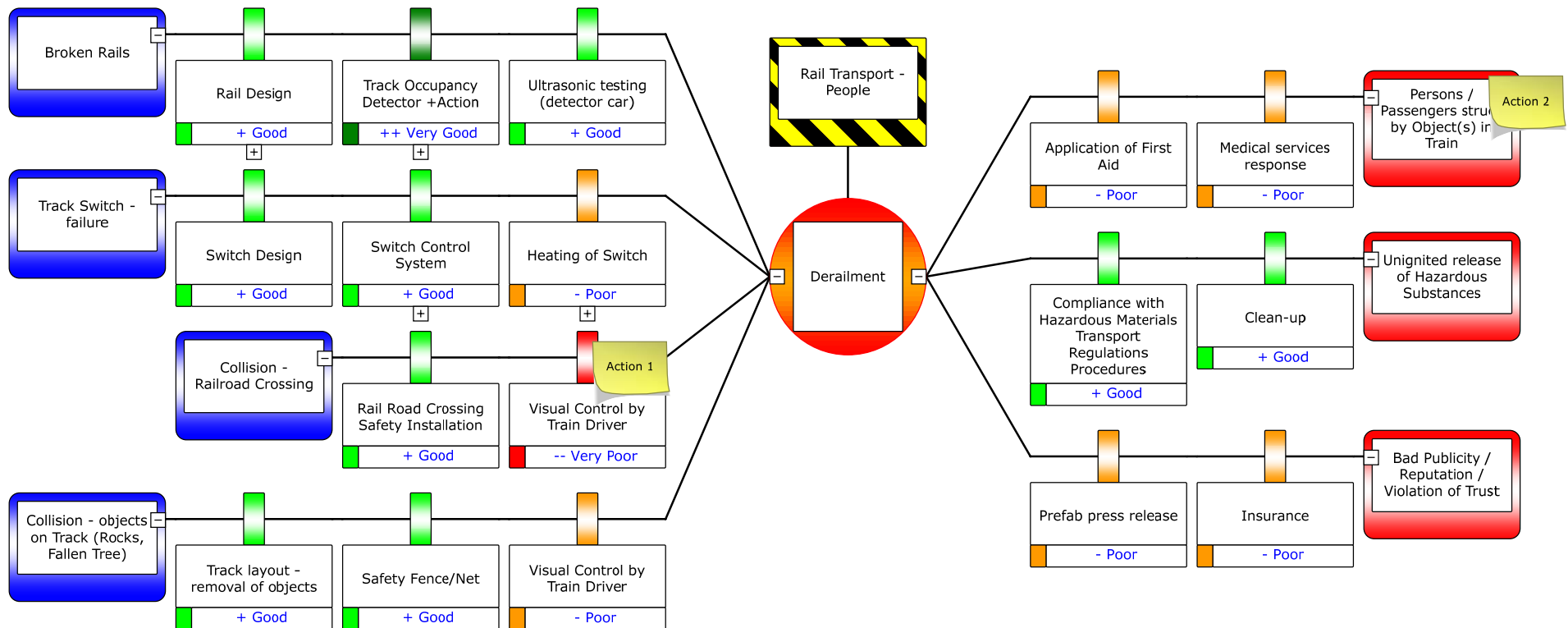
Oil & Gas



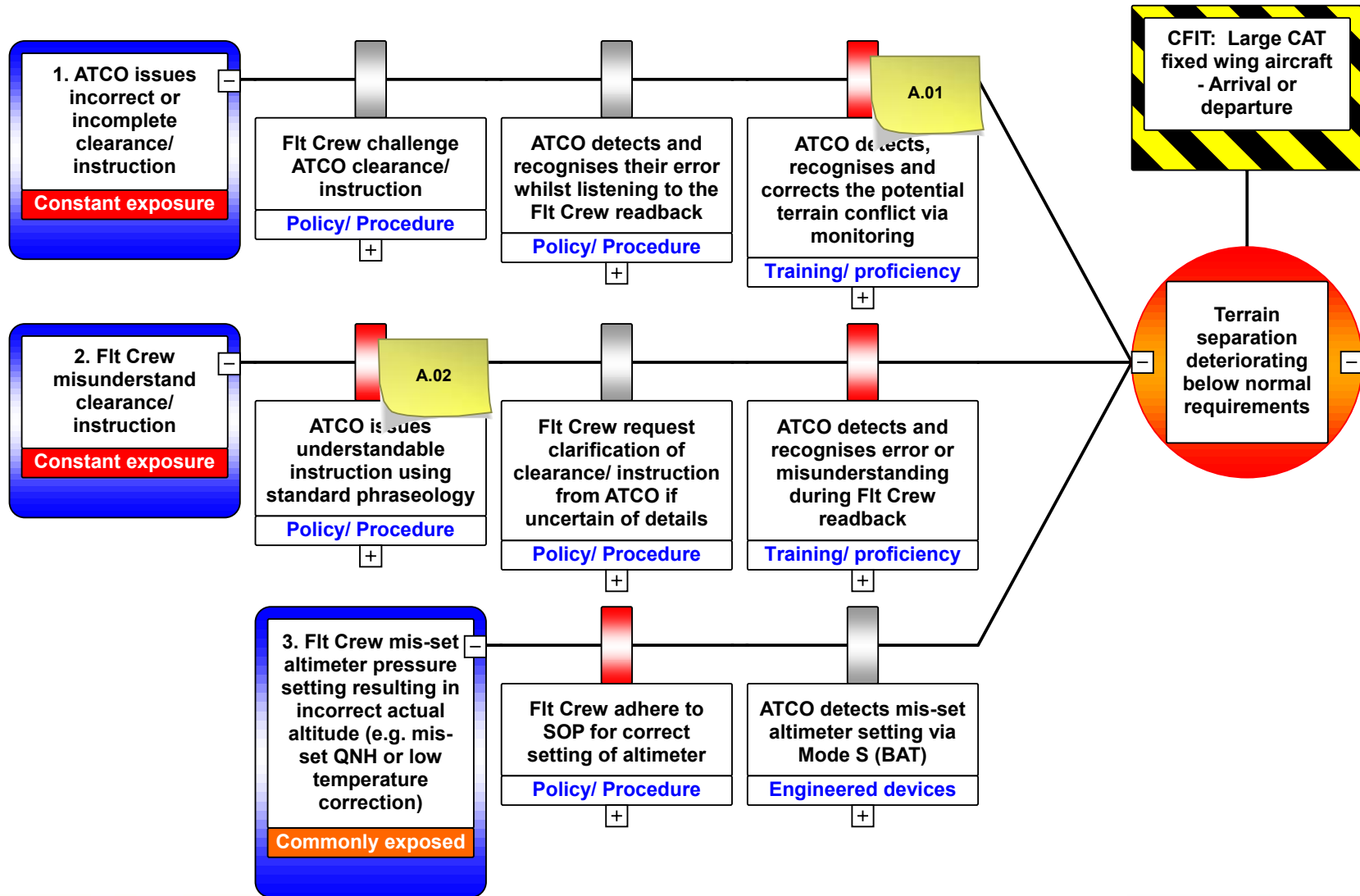
Construction (Project)



Rail transport

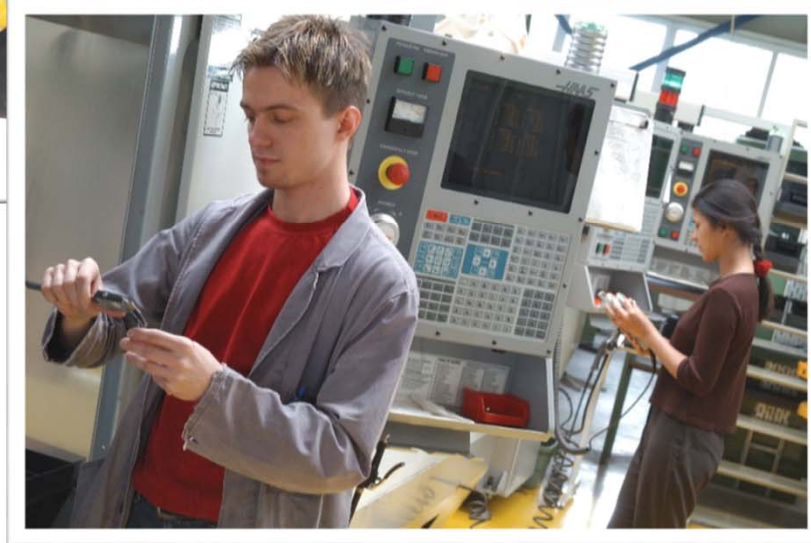


Aviation

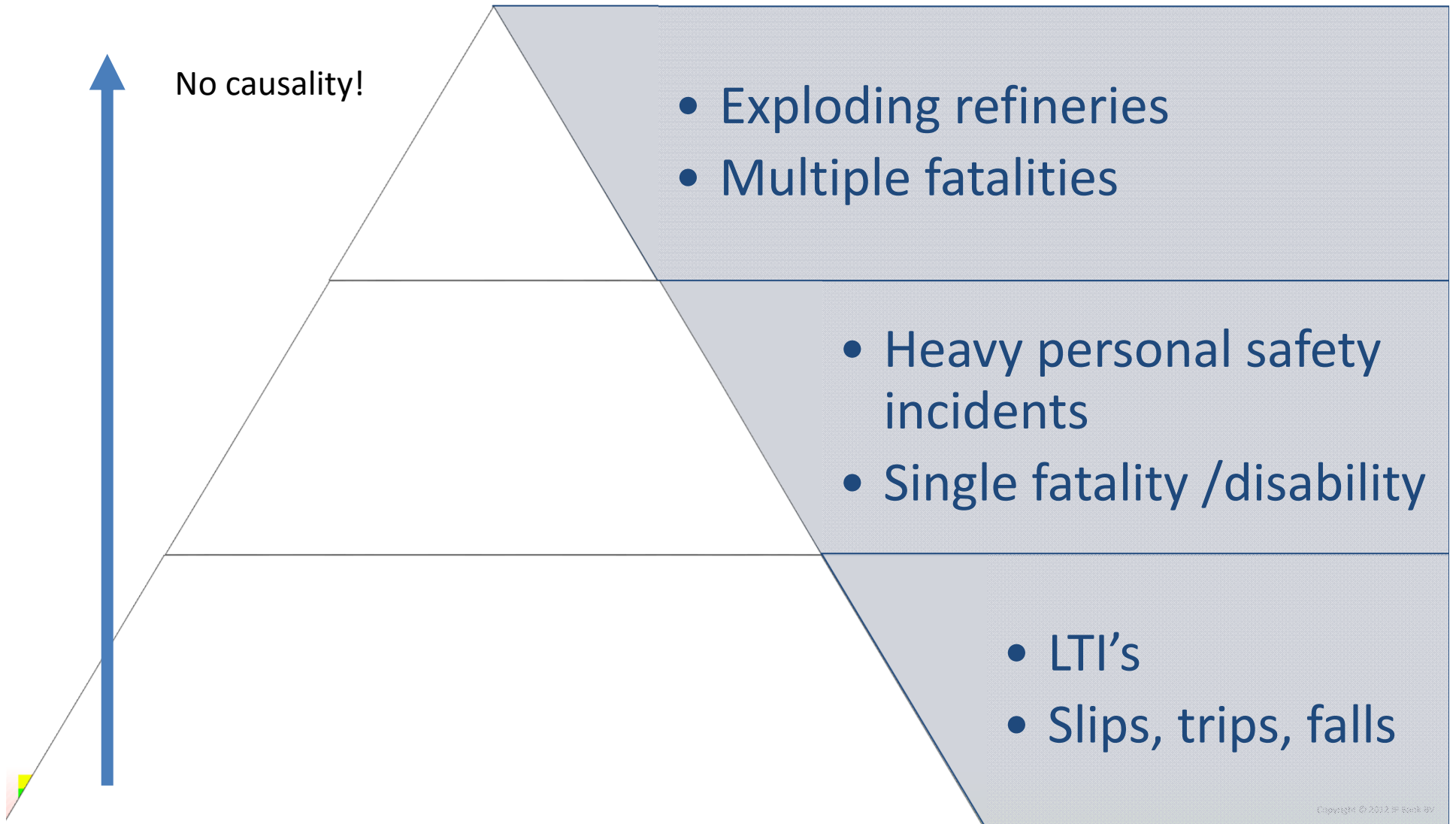


Why Bowtie risk assessment?

Complexity

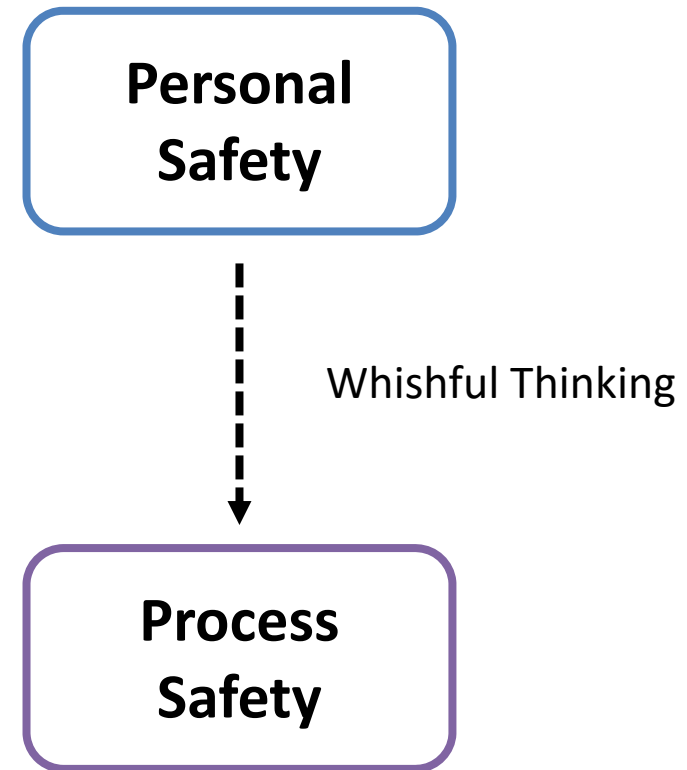


Incident pyramid

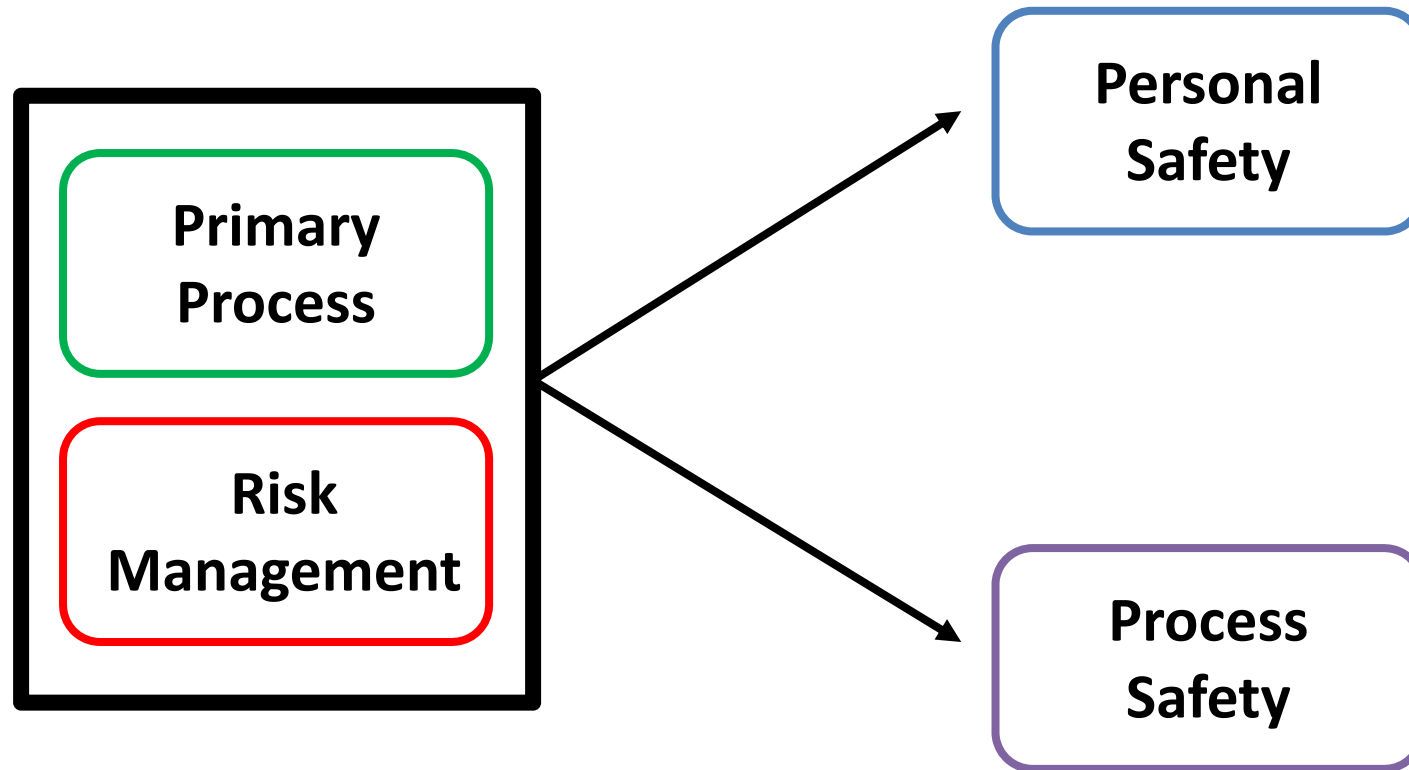




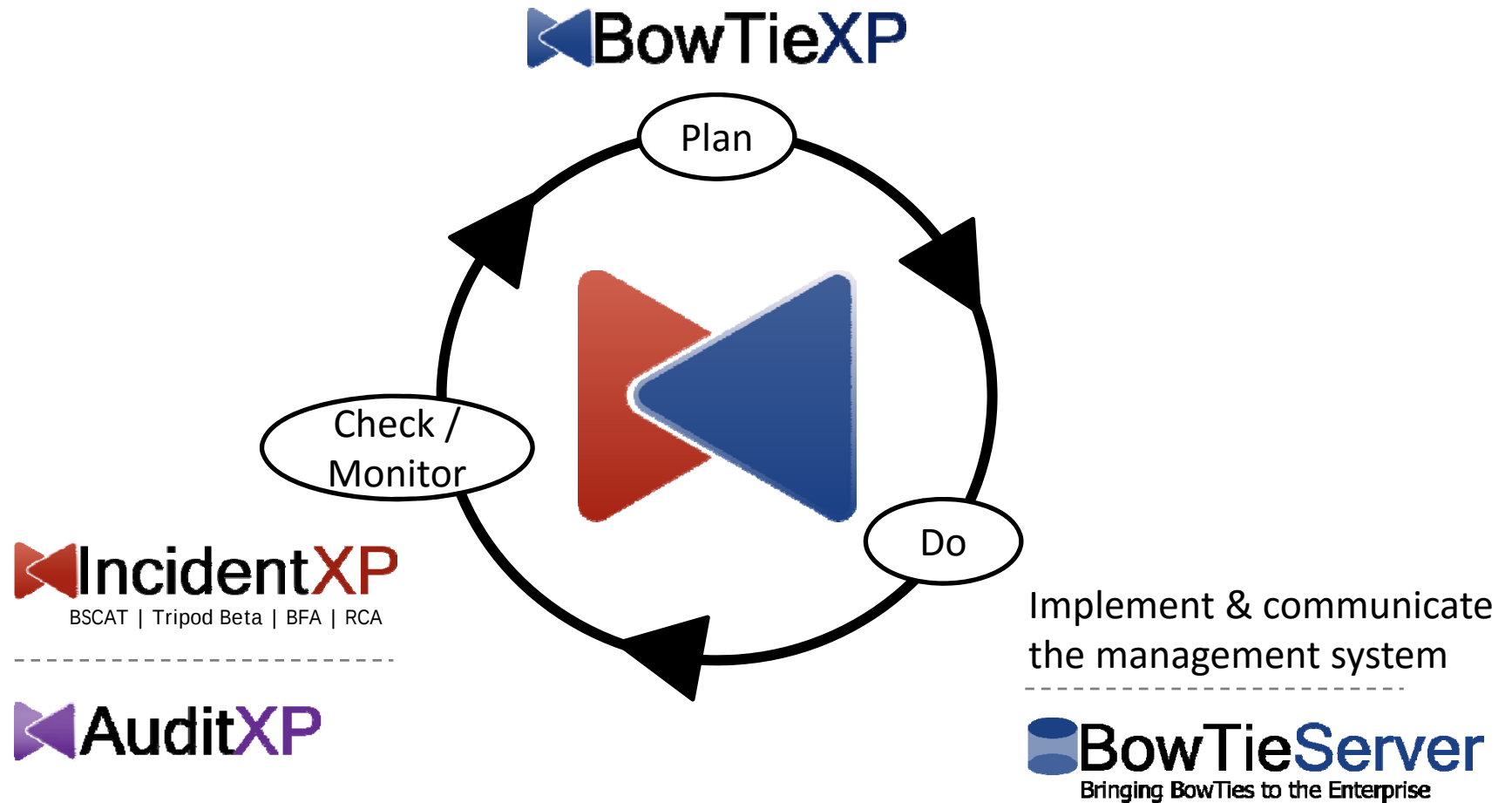
Risk management = safety management?



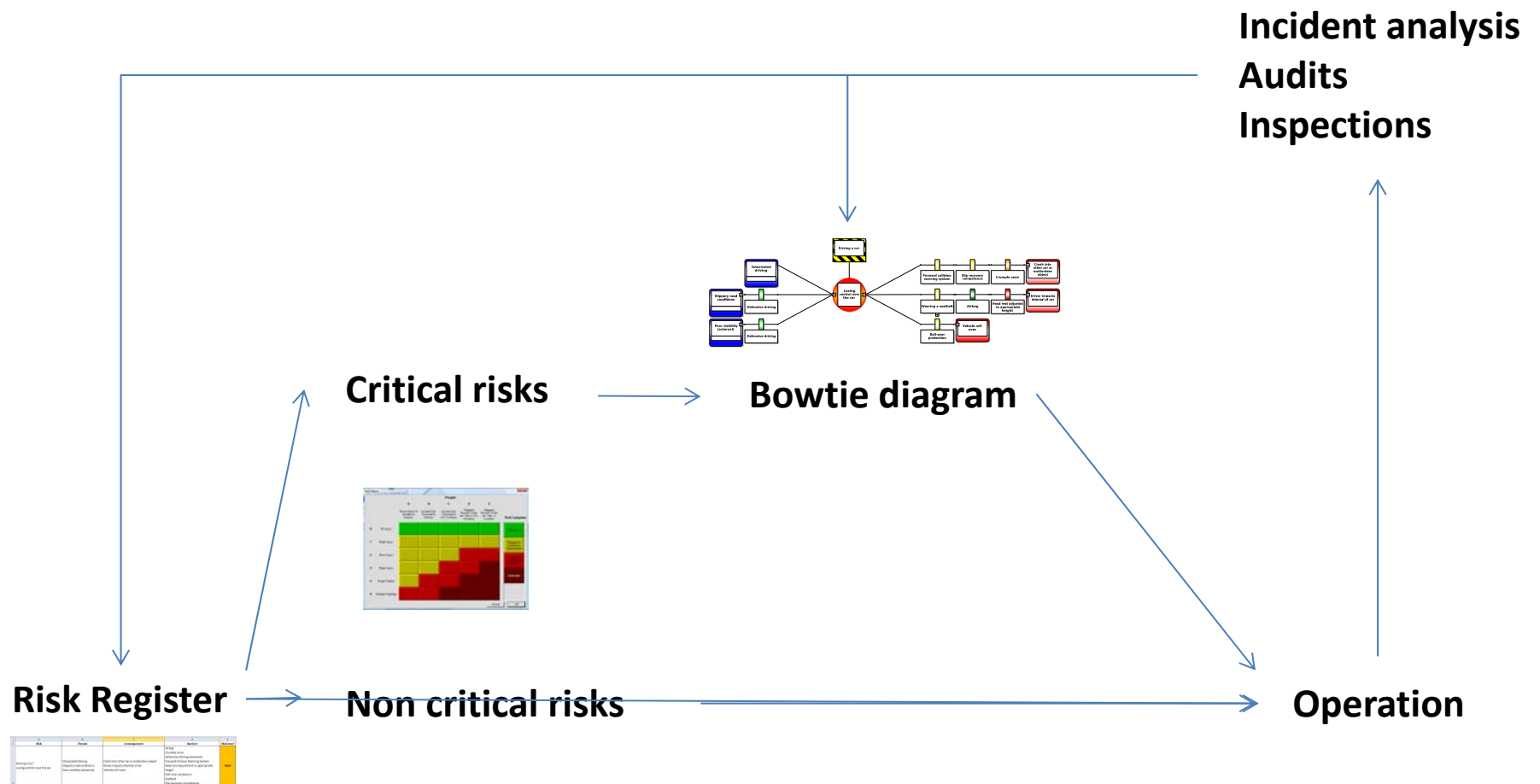
Risk management = safety management?



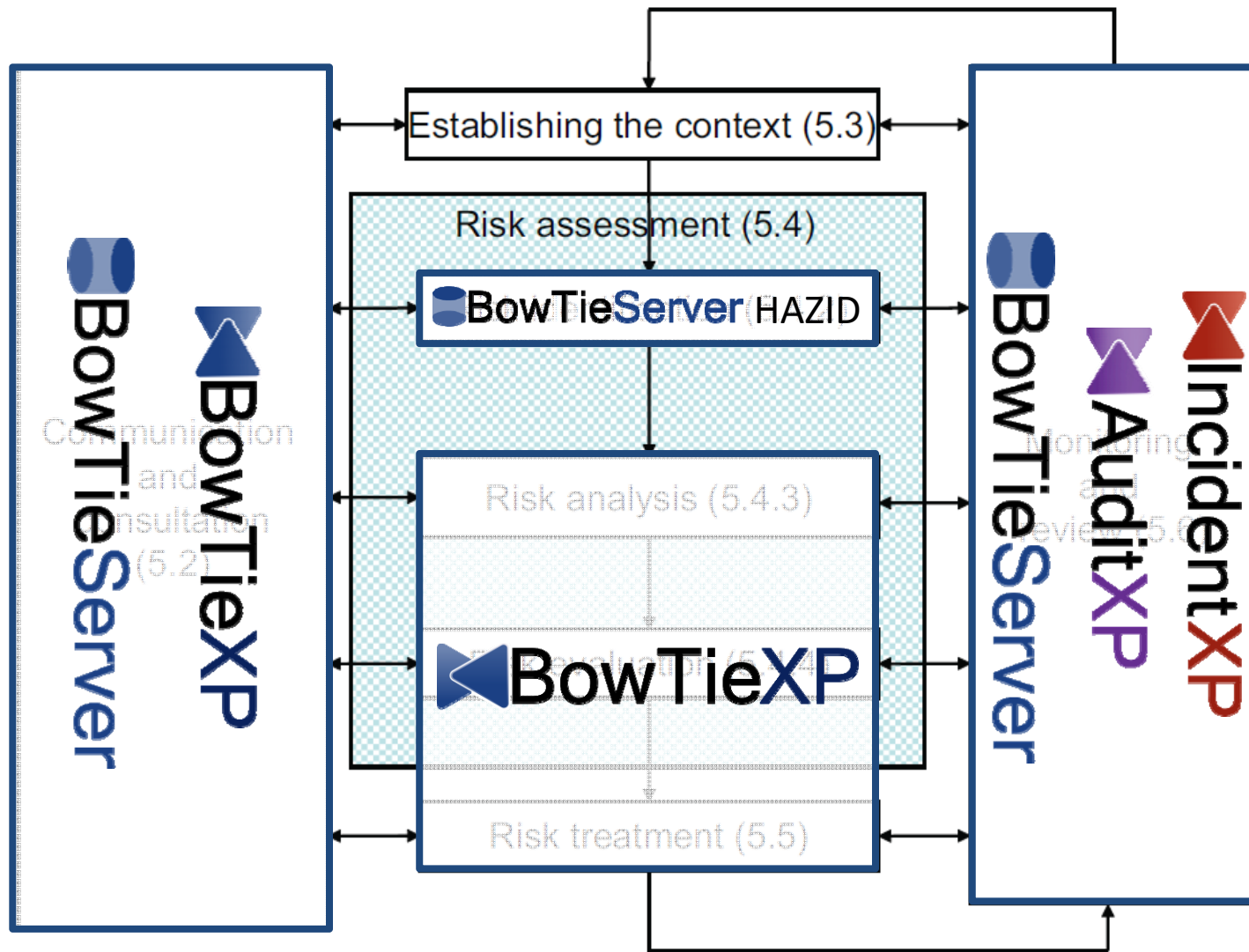
First step



Risk Management Process



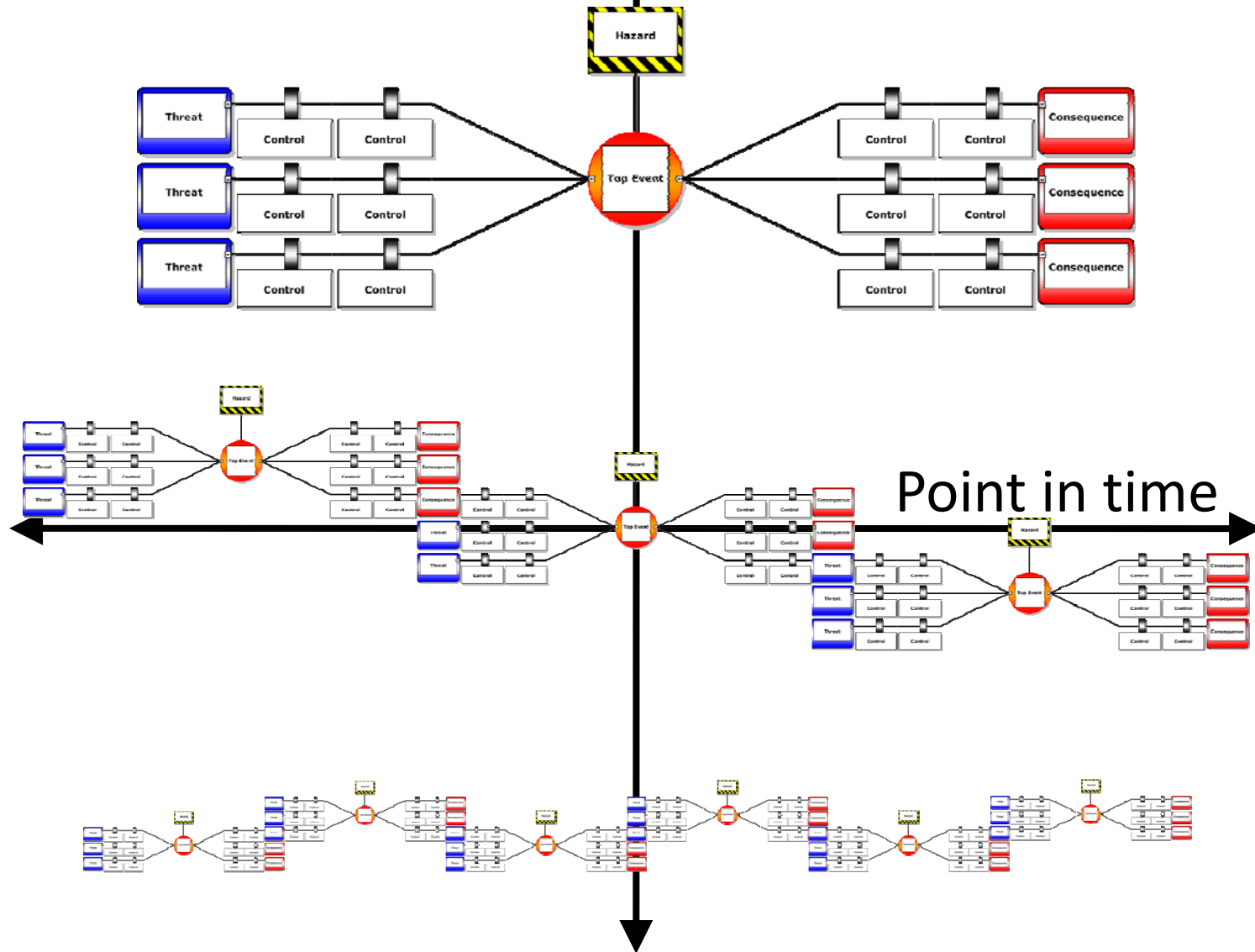
ISO 31000



Establishing the context

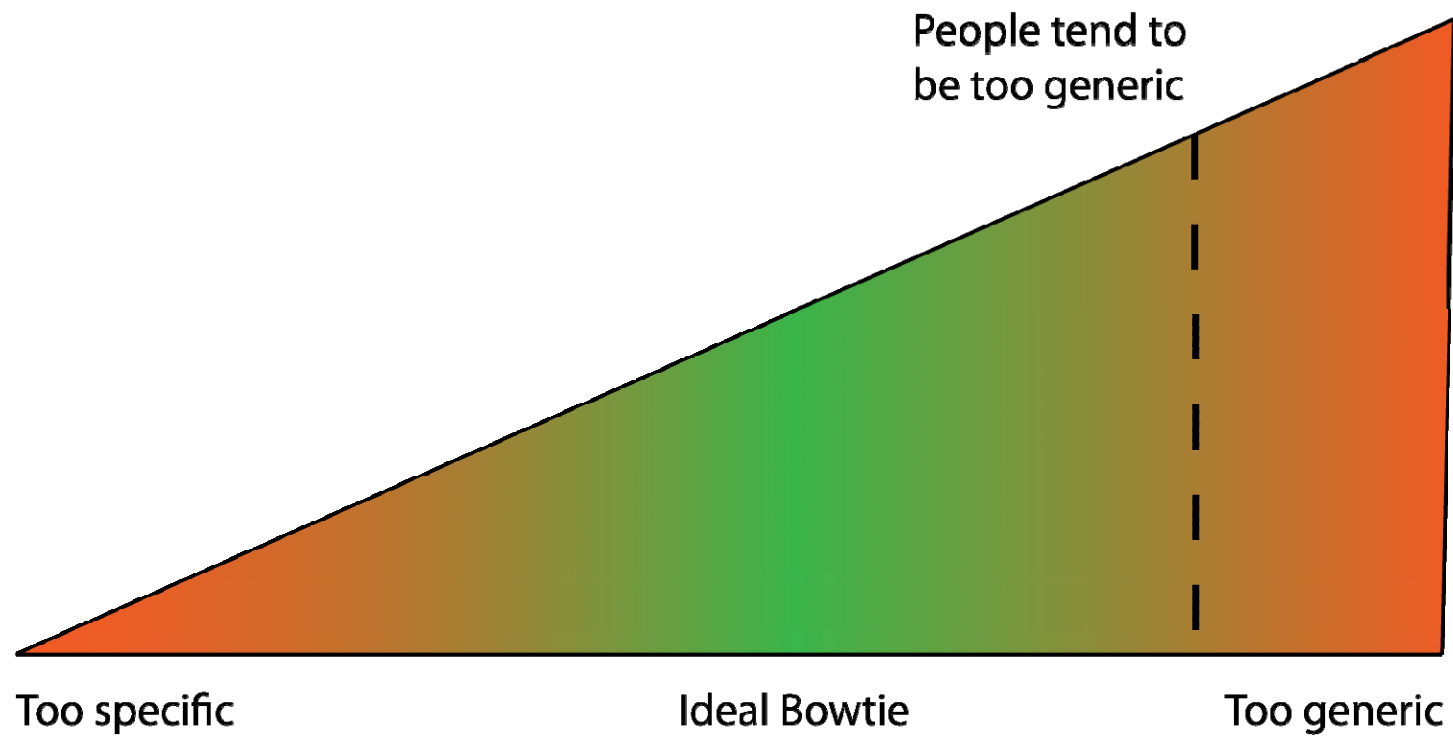
-  What problem do we want to solve?
-  Who are the Bowties for?
-  Which locations will we include?
-  What can we do in terms of resources (e.g. time, money)?
-  Which process, techniques will we use?
-  When have we succeeded?

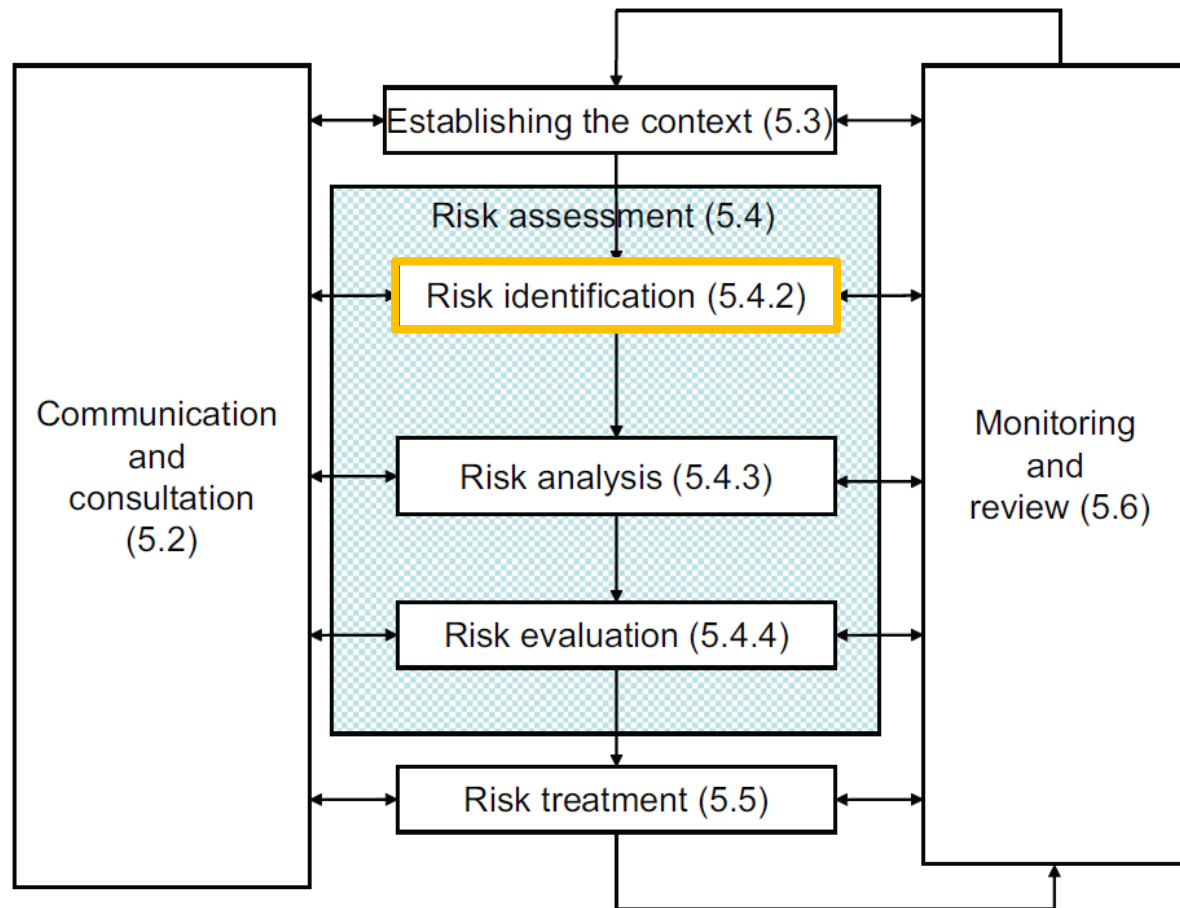
Zoom-level ↑



Point in time →

Zoom level





Risk identification

The aim of this step is to generate a comprehensive list of risks.

HAZID as starting point

Pick out the high potential hazards to do a Bowtie on

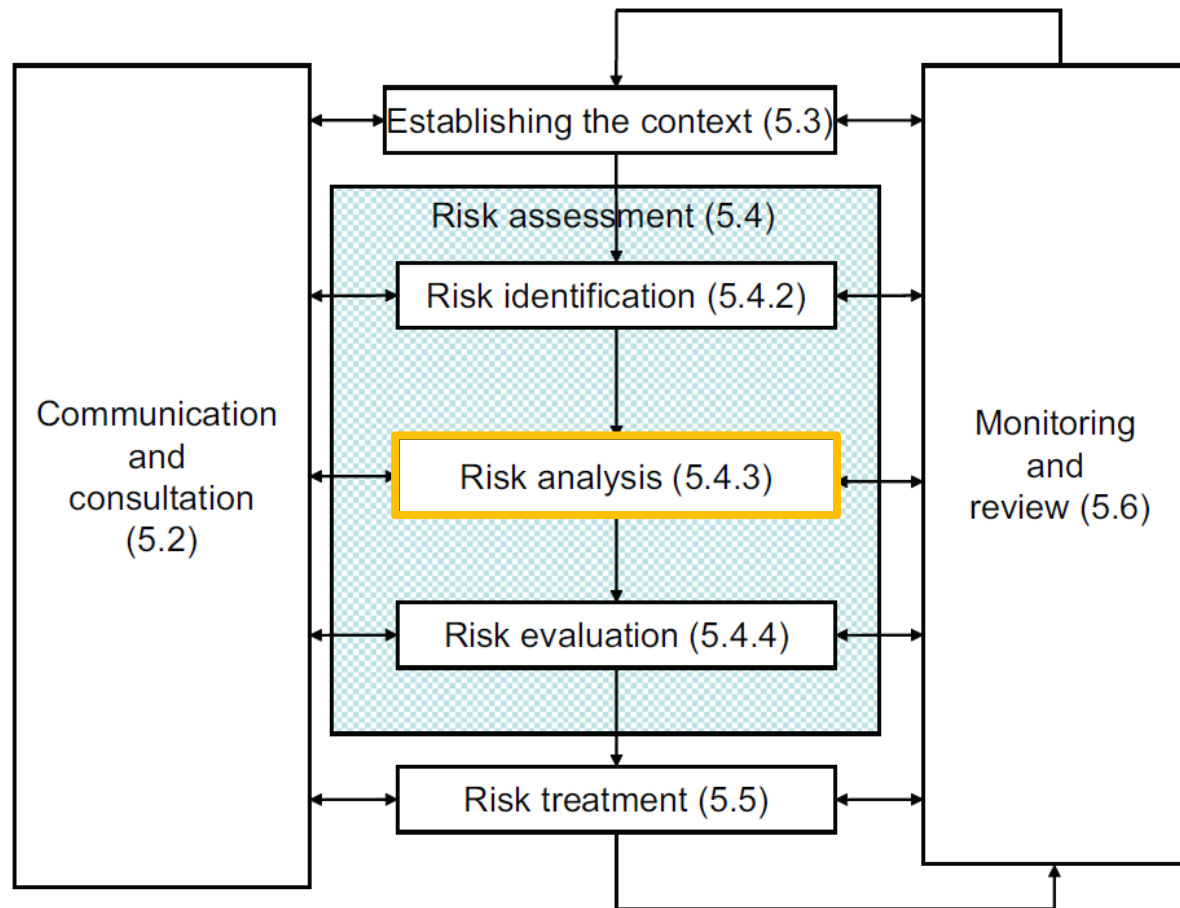
ITP - Joint Industry Project

FMECA Log Sheet - Node 1

ID	FUNCTION	ISSUES	FAILURE MECHANISM	FAILURE EFFECT	SAFEGUARD	Consequenc Likelihood	Criticality	COMMENTS	ACTION ITEMS	Test	Analysis	Experience	Procedure
1.06.04		Welding quality	Undermatch in weld could overstress the weld due to differential expansion effects.	Potential fracture of the pipeline and leak of LNG to the environment	Filler material will be chosen to achieve overmatch (except INVAR use) Weld qualification (partial for the JIP) NDT	4	3	M	Procedure will be written for the JIP	3		7	3
1.07.00	End Bulkheads - Stainless Steel												
1.07.01		Corrosion (external)			Coating will be applied, CP design	3	2	L					
1.07.02		Transitions between different material				4	3	M	see item 1.06.01				
1.07.03		Stresses loads	Over stress due to additional load from no centric pipes.	Possible yielding of the pipe	Possible stress effects should be accounted for in the design.	4	2	M	The pipes shall not be installed with centralizers.		6	6	
1.08.00	End Bulkheads - Carbon Steel												
1.08.01		Transitions between different material				4	3	M	see item 1.06.01				
1.08.02		Stresses loads	Metallurgical transitions between carbon and stainless steel	Localized overstress	FEA analyses, NDT, QA/QC	4	3	M			6	6	
1.09.00	Pipeline Bend												
1.09.01		Mechanical properties affected from induction bending			Bend qualification procedures (QA/QC)	2	3	L	Potential for wrinkling during fabrication		7		
1.09.02		Fatigue due to Jetty motions	Fatigue/Fracture			4	2	M	Must be designed.				

HAZID as starting point

	A	B	C	D	E
1	Risk	Threats	Consequences	Barriers	Risk level
2	Driving a car / Losing control over the car	Intoxicated driving Slippery road conditions Poor visibility (external)	Crash into other car or motionless object Driver impacts Internal of car Vehicle roll-over	Airbag Crumple zone Defensive driving procedure Forward Collision Warning System Head rest adjustment to appropriate height Roll-over protection Seatbelt Slip recovery competence	Med



Risk analysis

[..] involves developing an **understanding of the risk.**

Bowtie uses

We use it to **Structure thinking**

We use it for **Risk based decision making**

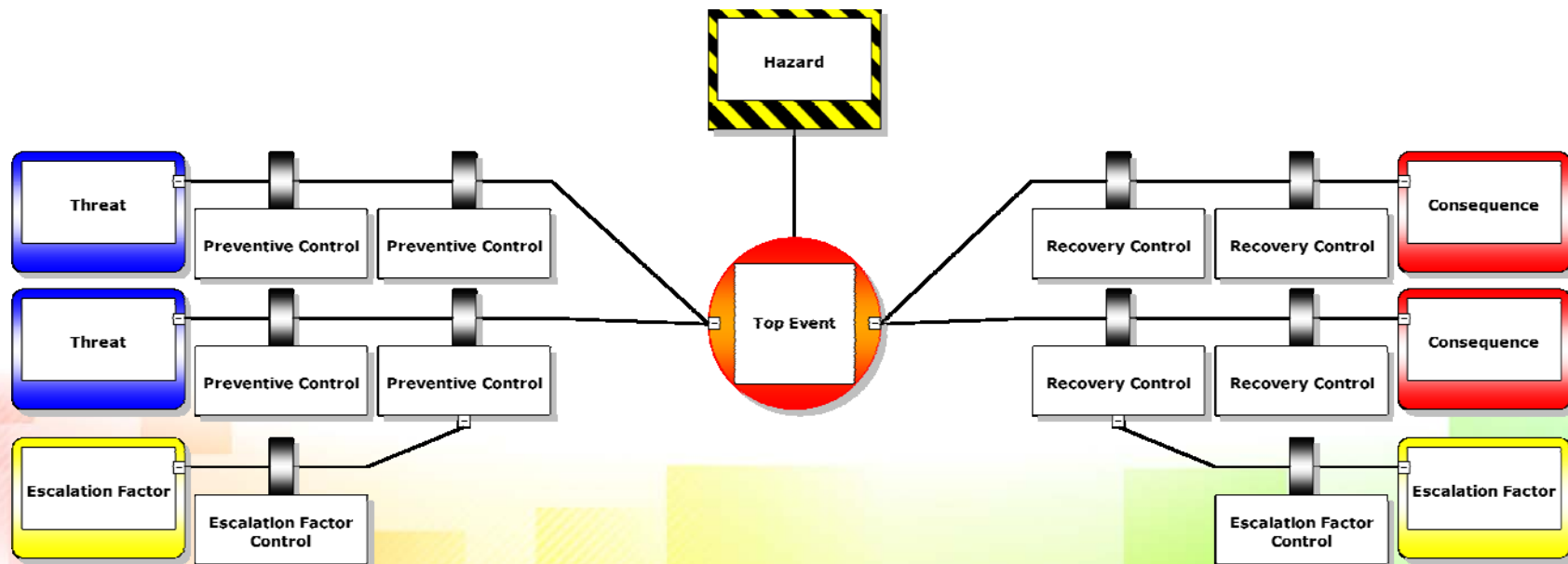
We use it for **Communication & Training**



6 very specific advantages of a BowTie

LOCATION	ITEM	EFFECTS OF HAZARD IDENTIFIED	RISK ASSESS	RISK CONTROL
All Offices	General office work, Operation of office equipment (computers, photocopiers)	Manual Handling & Ergonomics Electrical Safety	Very Low-Low	Staff Induction and Training Refer to University Guidelines for Manual Handling and Ergonomics Refer to Equipment Operation Manuals and other relevant SOP's
All Laboratories	General laboratory work, preparation of chemical reagents, experiments involving chemicals	Manual Handling & Ergonomics Chemical exposure Electrical Safety	Medium	Staff Induction and Training Refer to University Policy on Guidelines for Laboratory Conduct Refer to University Chemical Management Policy Guidelines Refer to Chemical MSDS and follow recommendations Maintain Chemical Register Refer to Equipment Operation Manuals and other relevant SOP's
Specialist Laboratories	As above, but includes Quarantine and PC labs, Radioisotope Labs, Analytical Facilities, Wine Science Laboratories	As above, but may include: Quarantine and PC Containment, Radiation Exposure, Working on Specialist Equipment or in Confined Spaces	Medium	As above, but may include: Refer to relevant Quarantine and PC Policies and Legislation Refer to relevant Radiation Policies and Legislation

YV1

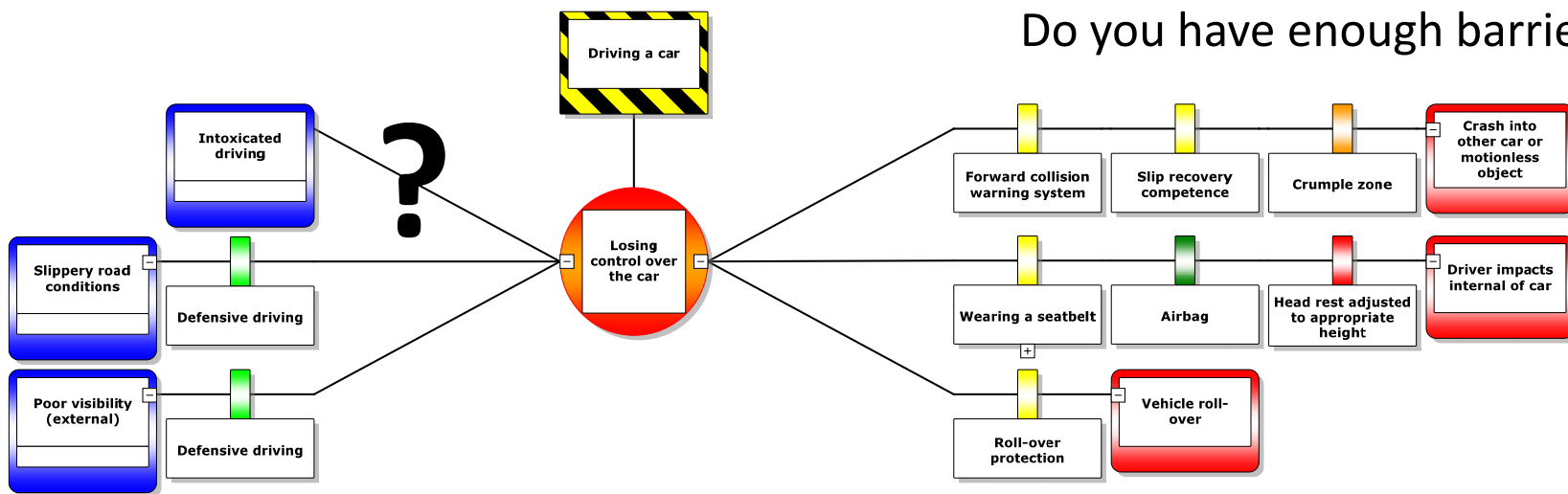


Risk analysis

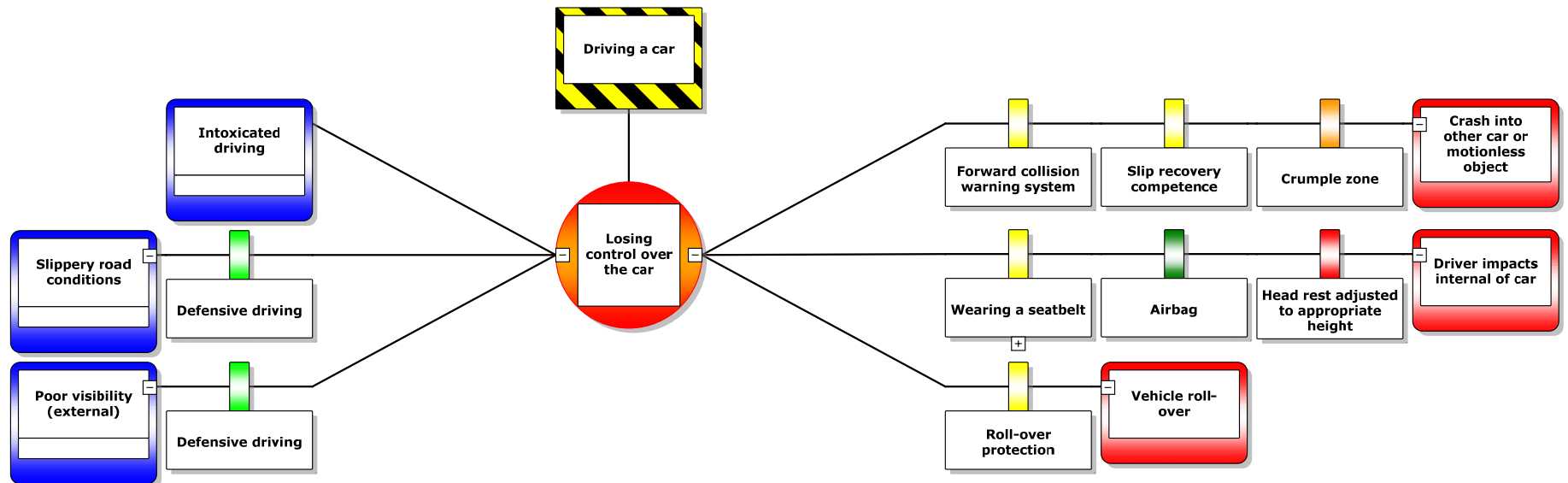
	A	B	C	D	E
1	Risk	Threats	Consequences	Barriers	Risk level
2	Driving a car / Losing control over the car	Intoxicated driving Slippery road conditions Poor visibility (external)	Crash into other car or motionless object Driver impacts Internal of car Vehicle roll-over	Airbag Crumple zone Defensive driving procedure Forward Collision Warning System Head rest adjustment to appropriate height Roll-over protection Seatbelt Slip recovery competence	Med



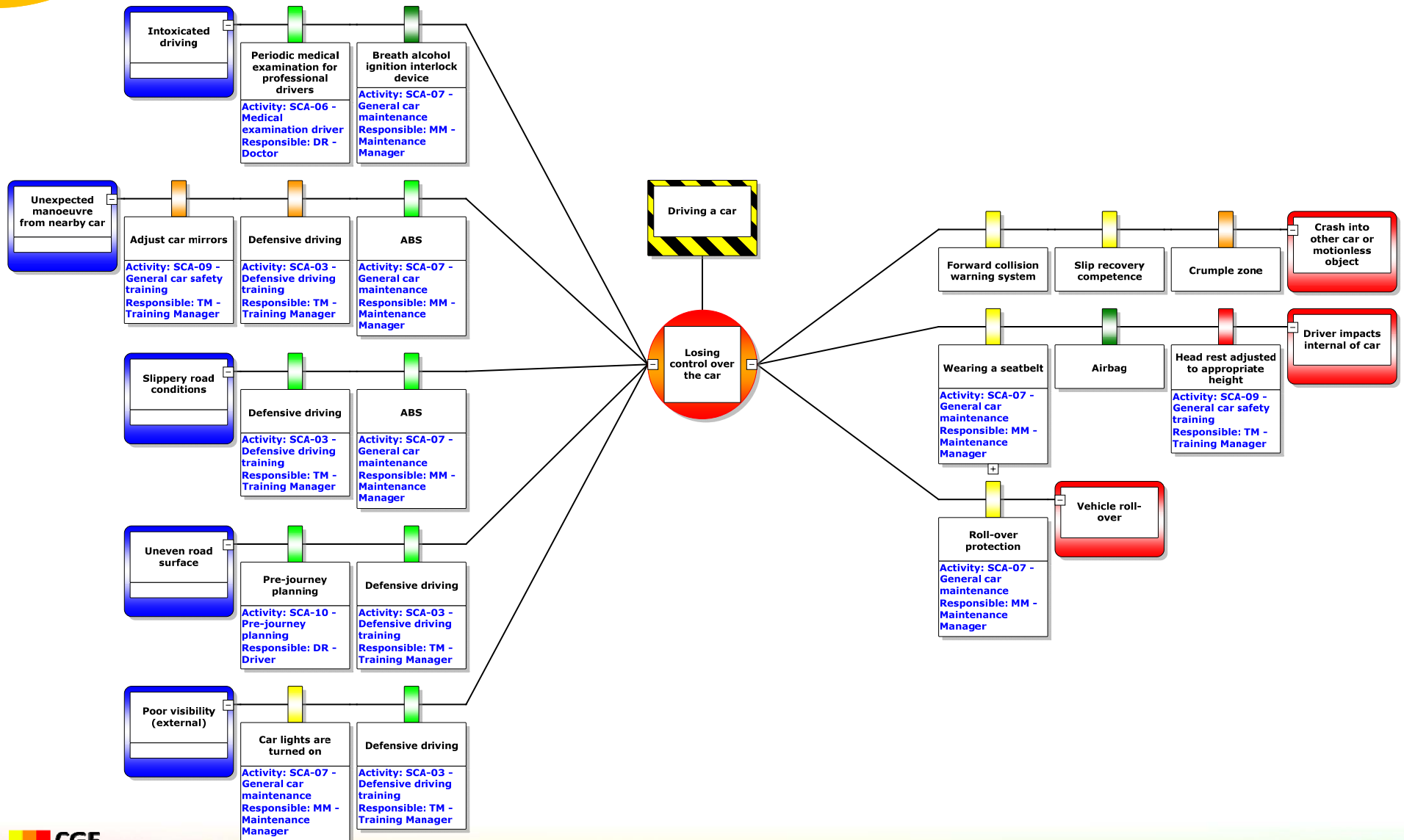
Do you have enough barriers?



Proactive or Reactive

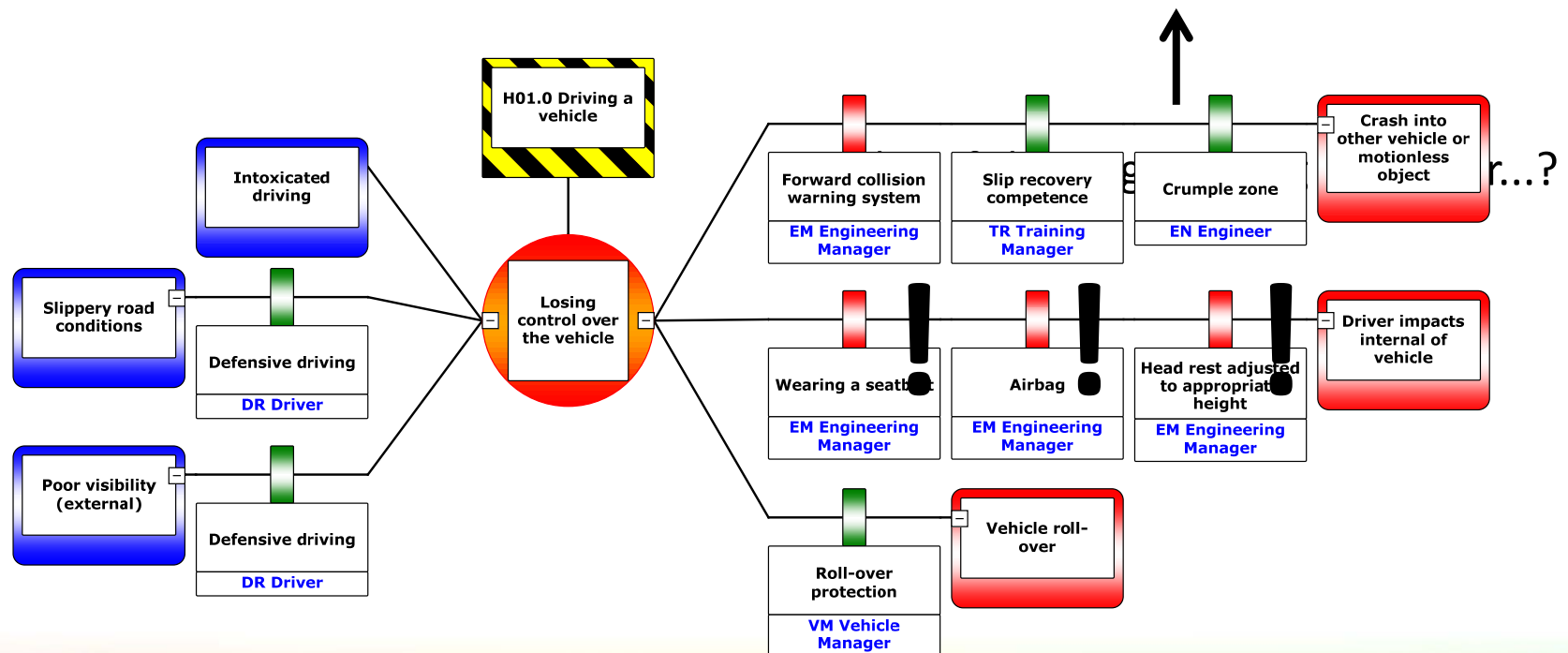


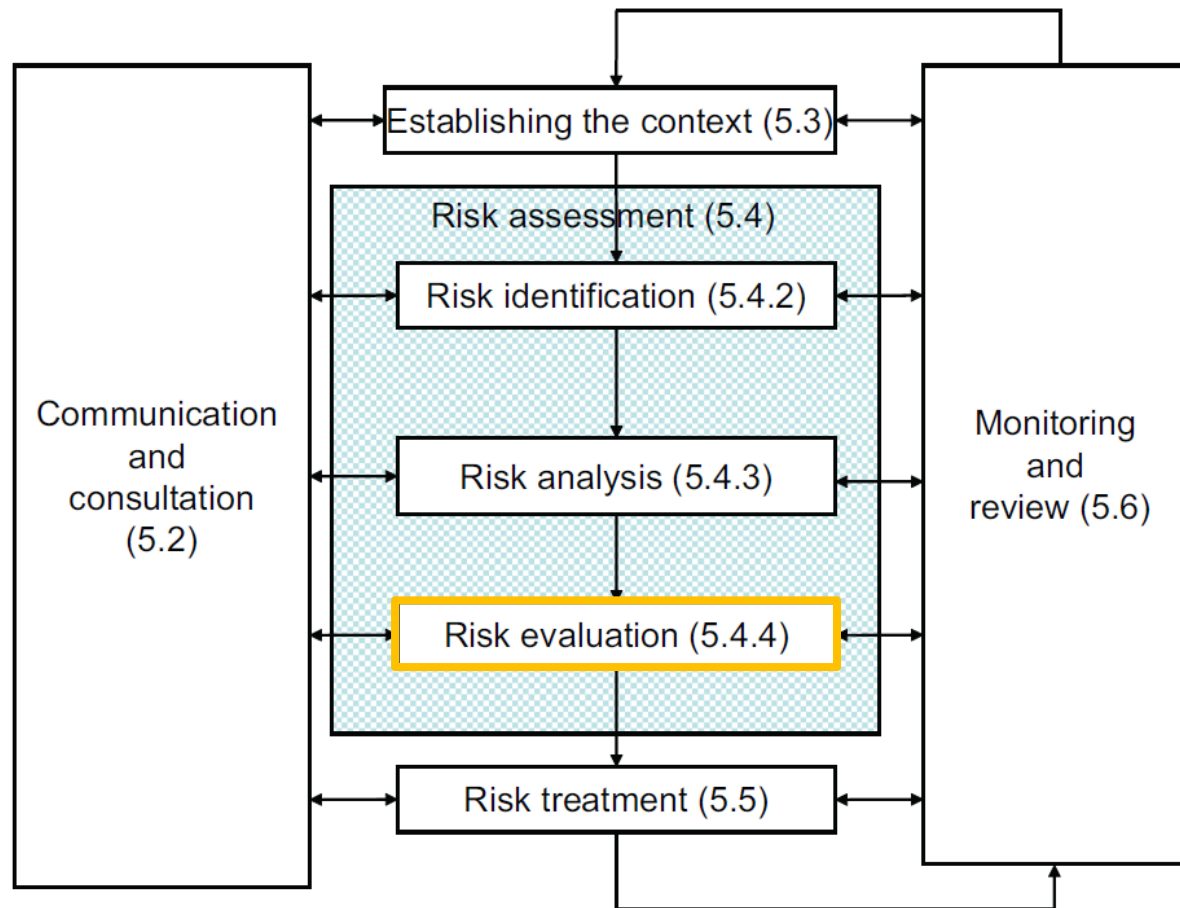
Risk based SMS



Understand independencies

	A	B	C	D	E
1	Risk	Threats	Consequences	Barriers	Risk level
2	Driving a car / Losing control over the car	Intoxicated driving Slippery road conditions Poor visibility (external)	Crash into other car or motionless object Driver impacts Internal of car Vehicle roll-over	Airbag Crumple zone Defensive driving procedure Forward Collision Warning System Head rest adjustment to appropriate height Roll-over protection Seatbelt Slip recovery competence	Med





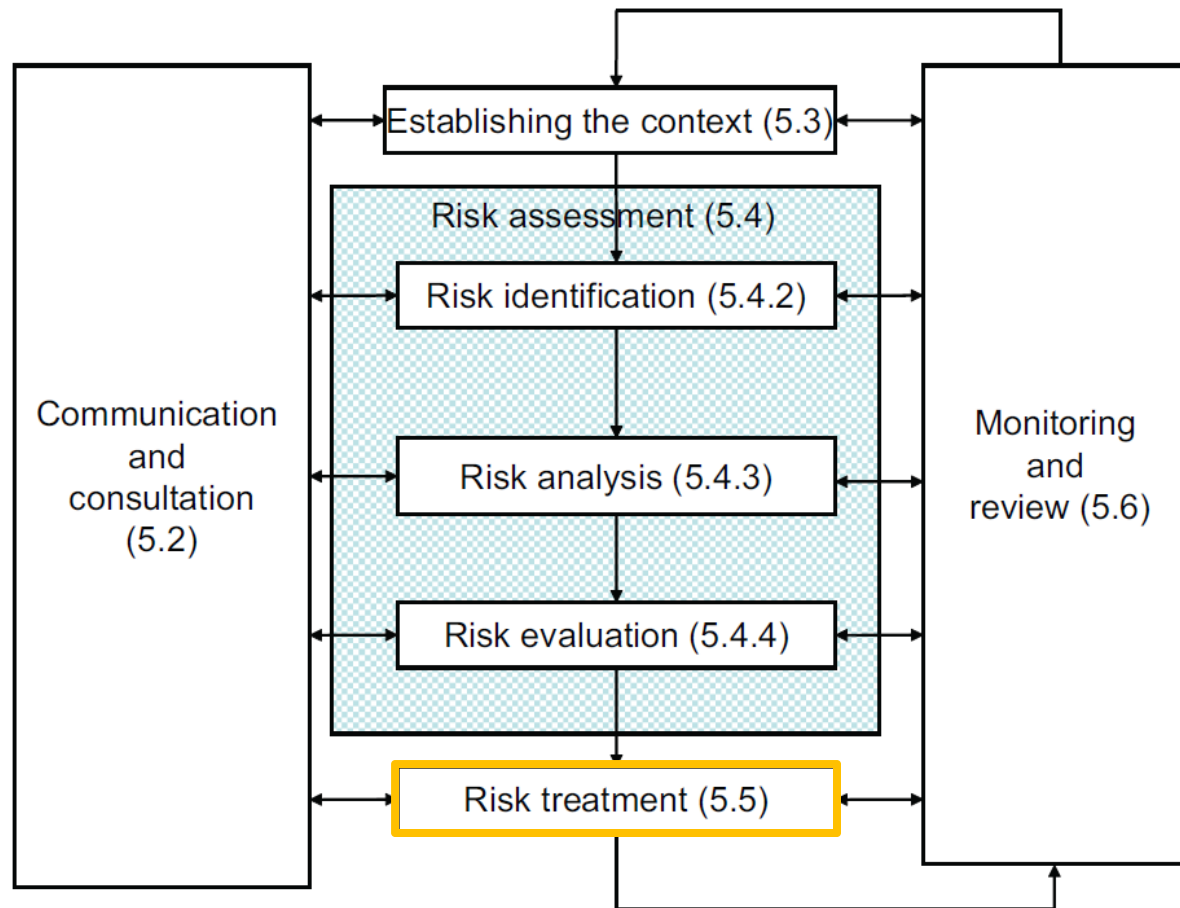
Risk evaluation

to assist in making decisions,[..] about **which risks need treatment** and the **priority** for treatment implementation.

Risk evaluation

	A	B	C	D	E
1	Risk	Threats	Consequences	Barriers	Risk level
2	Driving a car / Losing control over the car	Intoxicated driving Slippery road conditions Poor visibility (external)	Crash into other car or motionless object Driver impacts Internal of car Vehicle roll-over	Airbag Crumple zone Defensive driving procedure Forward Collision Warning System Head rest adjustment to appropriate height Roll-over protection Seatbelt Slip recovery competence	Med





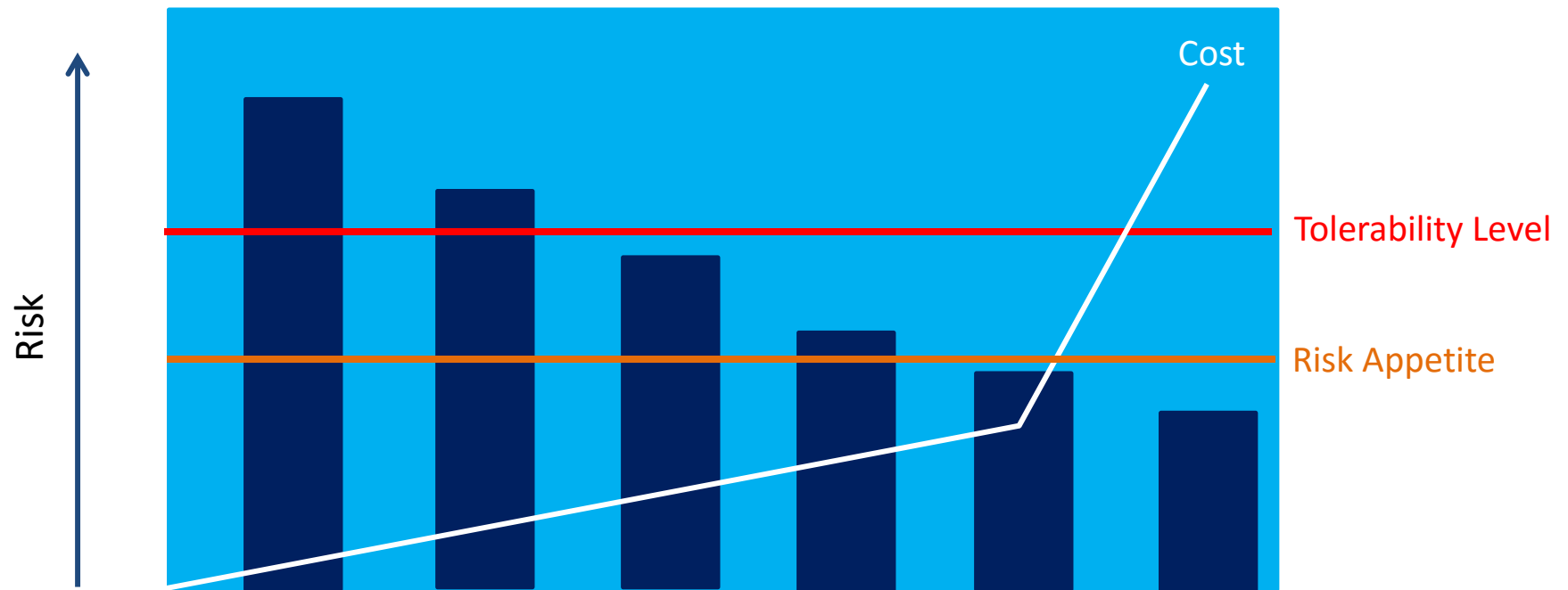
Risk treatment

selecting one or more options for **modifying risks**, and implementing those options.

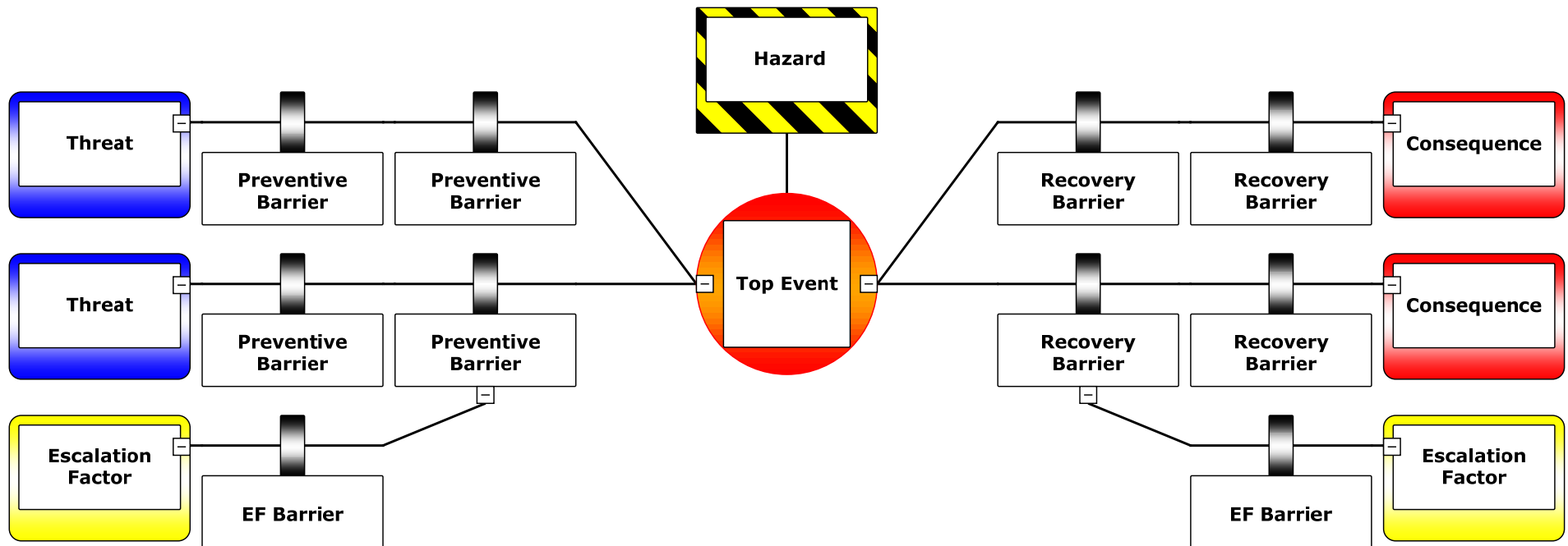
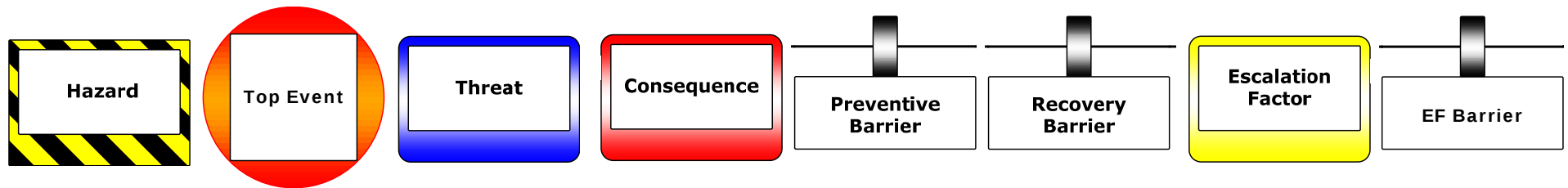
The ALARP Obligation

Reduce a risk to a level which is As Low As Reasonably Practicable:

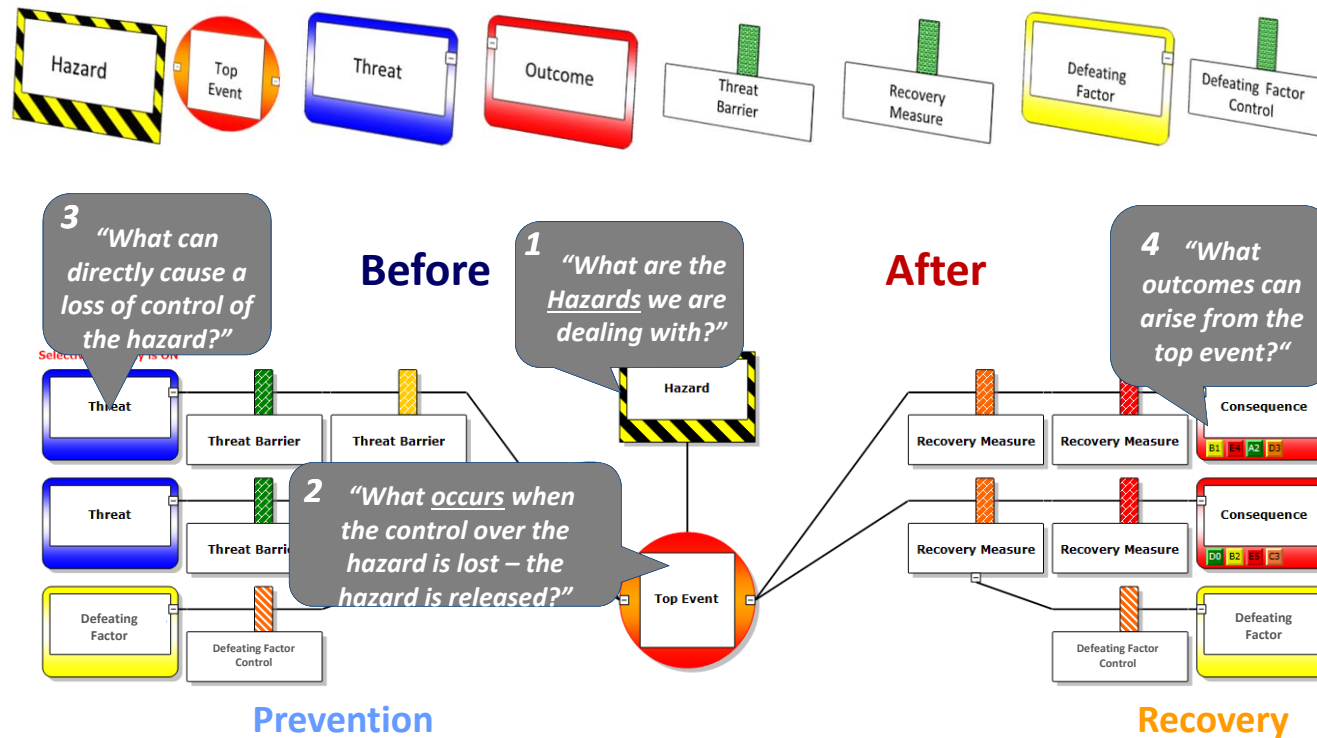
A balance of time, trouble, difficulty & cost.



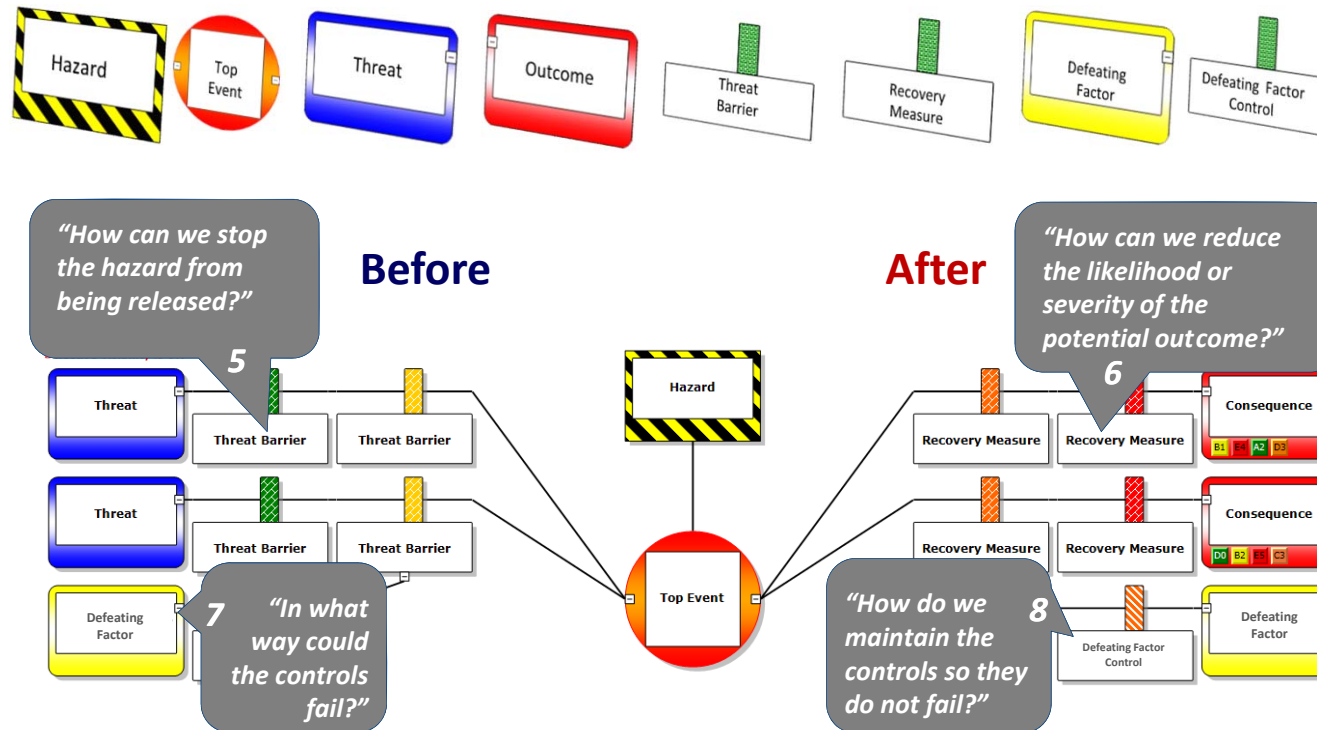
BowTie analysis in 8 steps



BowTie analysis - 8 steps



BowTie analysis - 8 steps



Step 1. Identify Hazards



Activity or state that has the potential to cause harm

Hazards are...



■ An activity or state, which, in case of failure, can lead to negative outcomes

■ Activities or states are part of normal business

■ Often involving energies – what are yours?

- Chemical
- Kinetic
- Gravitational
- Nuclear
- Thermal
- Pressure
- Biological
- ?



■ But also Social, Financial, Services, Organisational, etc.

■ Goal: Setting and defining scope for the bowtie diagram

Step 2. Define Top Event

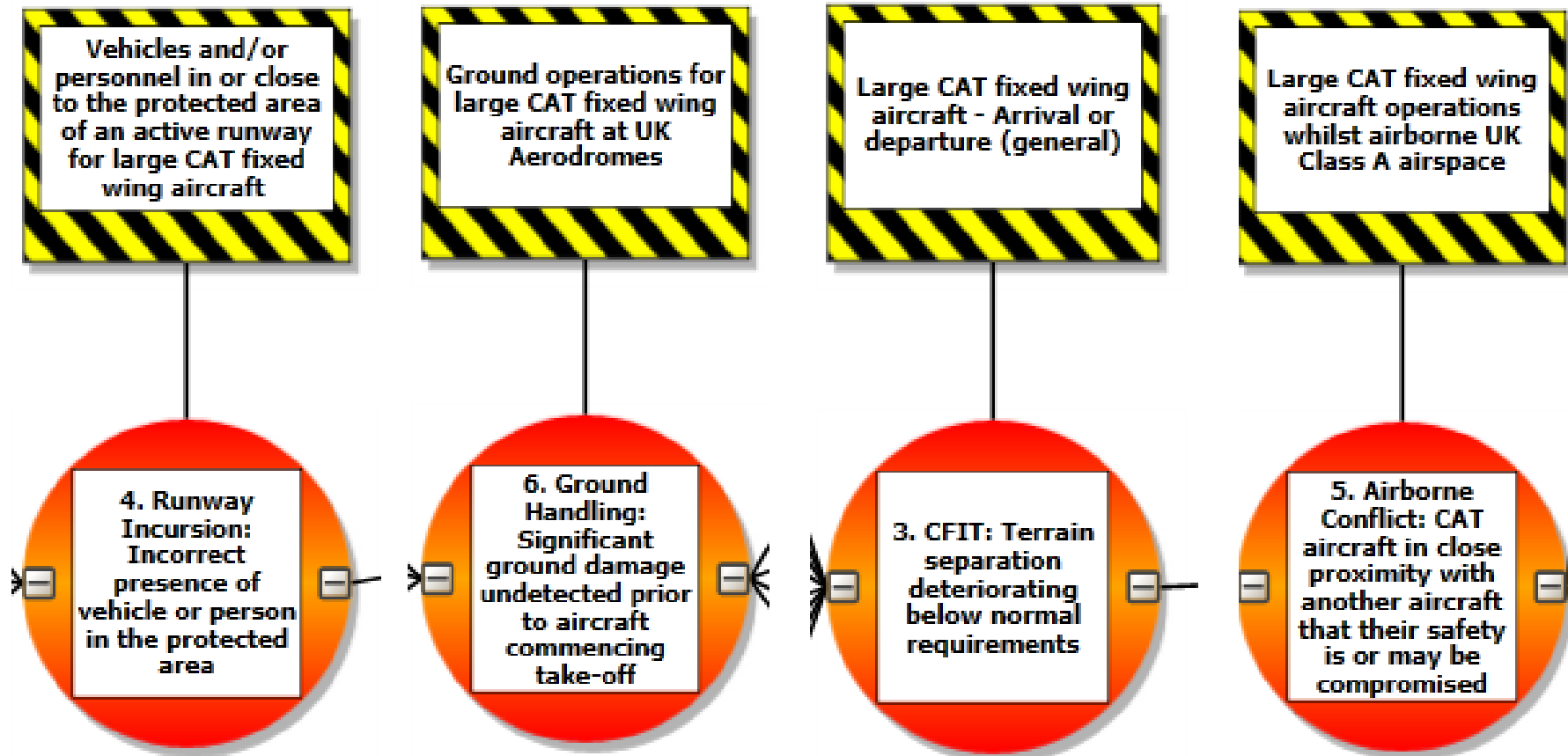


The point in time when control over
the Hazard is lost

Top Event



Top Event



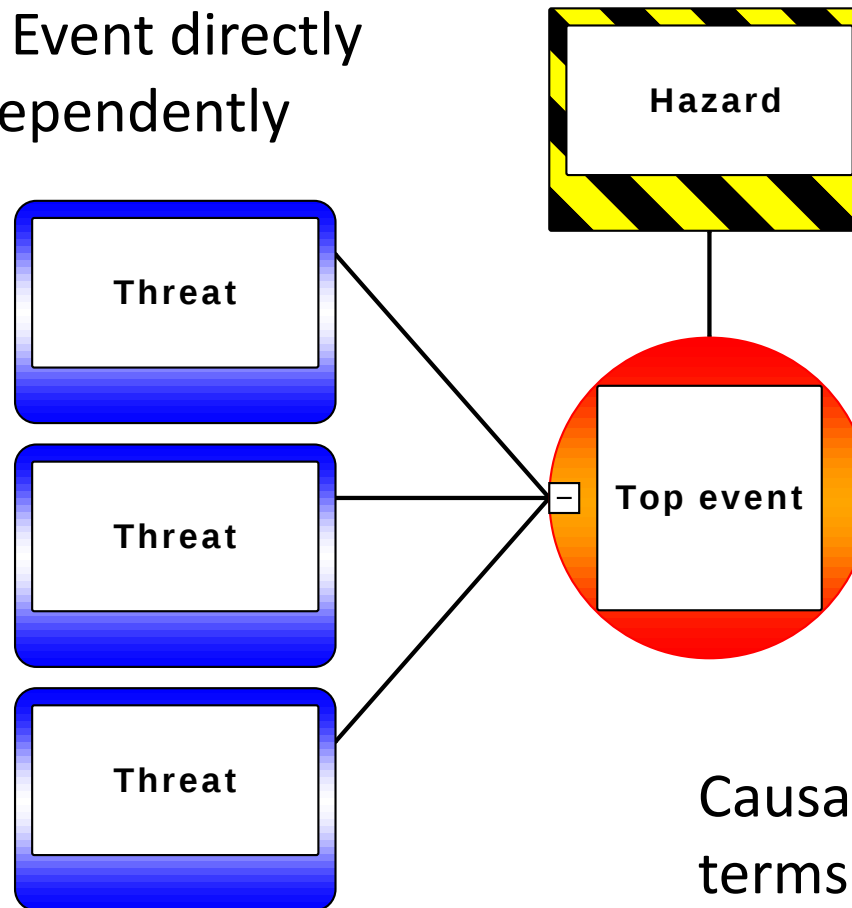
Step 3. Define Threats



**A possible cause for
the Top Event**

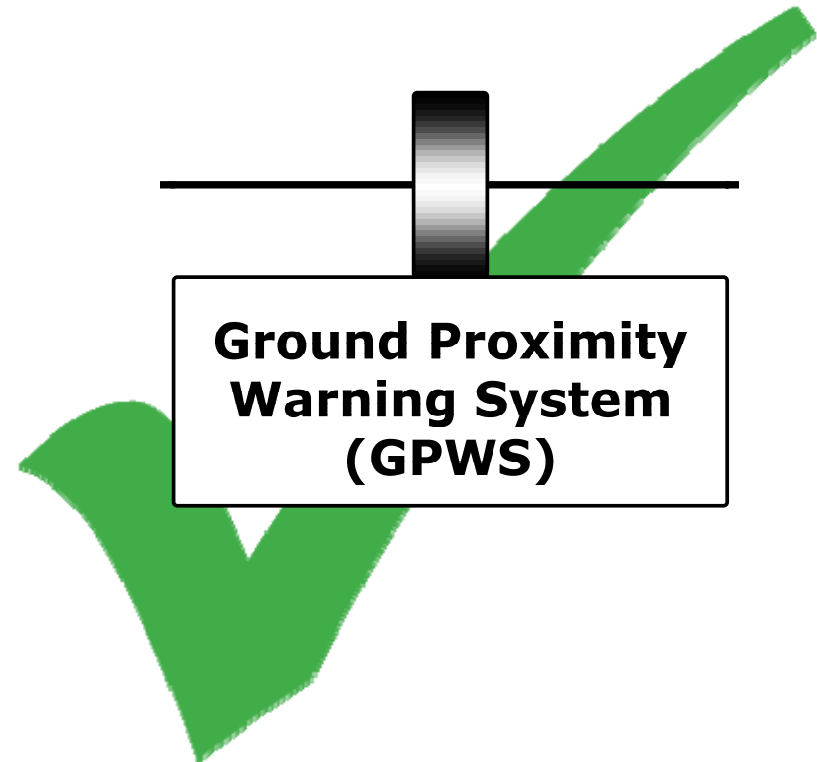
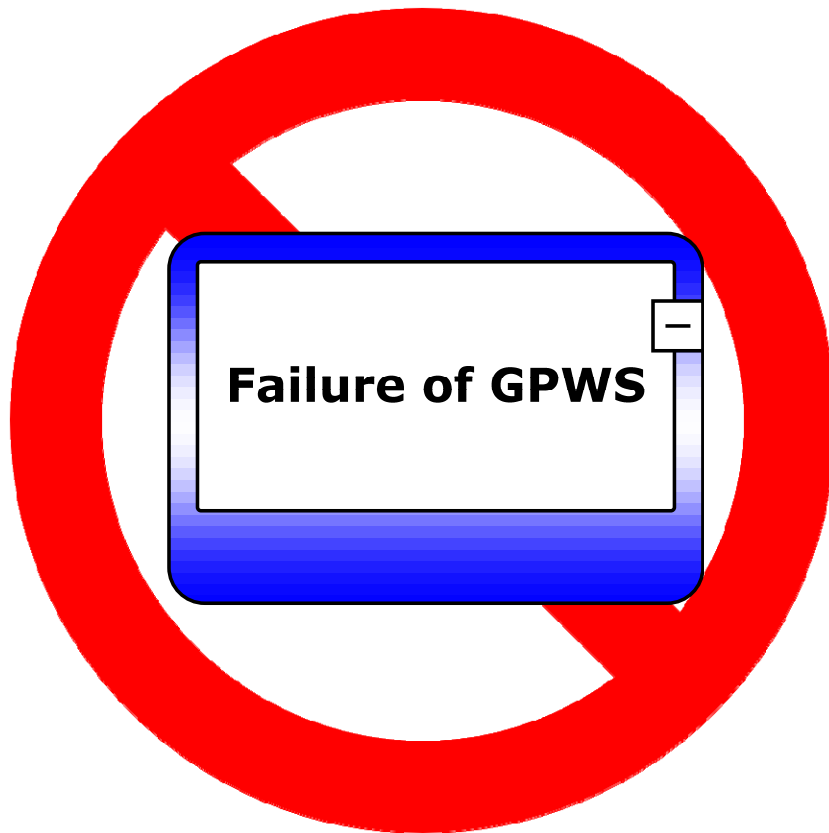
Threats

Threats should lead to the Top Event directly and independently



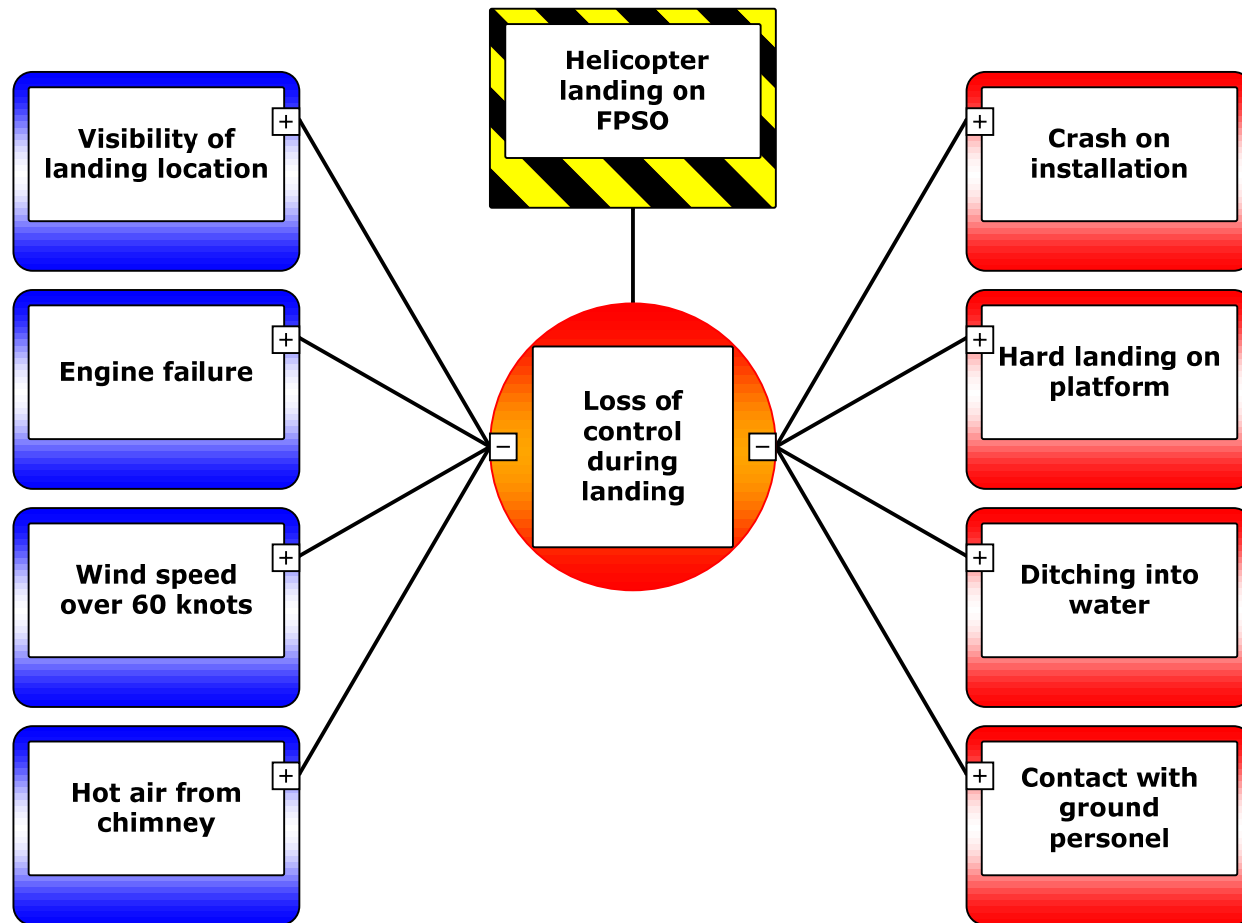
Causally direct, not in terms of time

Barrier Failures



Can be recognized by terms such as: Lack of, Failure of, absence of...

Threats



Step 4. Define Consequences

Consequence

An unwanted event caused by the Top Event

Damage vs. Events

- Injury / fatality
- Equipment damage
- Environmental damage
- Reputation damage



- Go into Risk matrices on Consequences



- Smoke inhalation / blunt impact
- Object impacts live equipment
- Oil spill into sea

Step 5 & 6. Defining Barriers

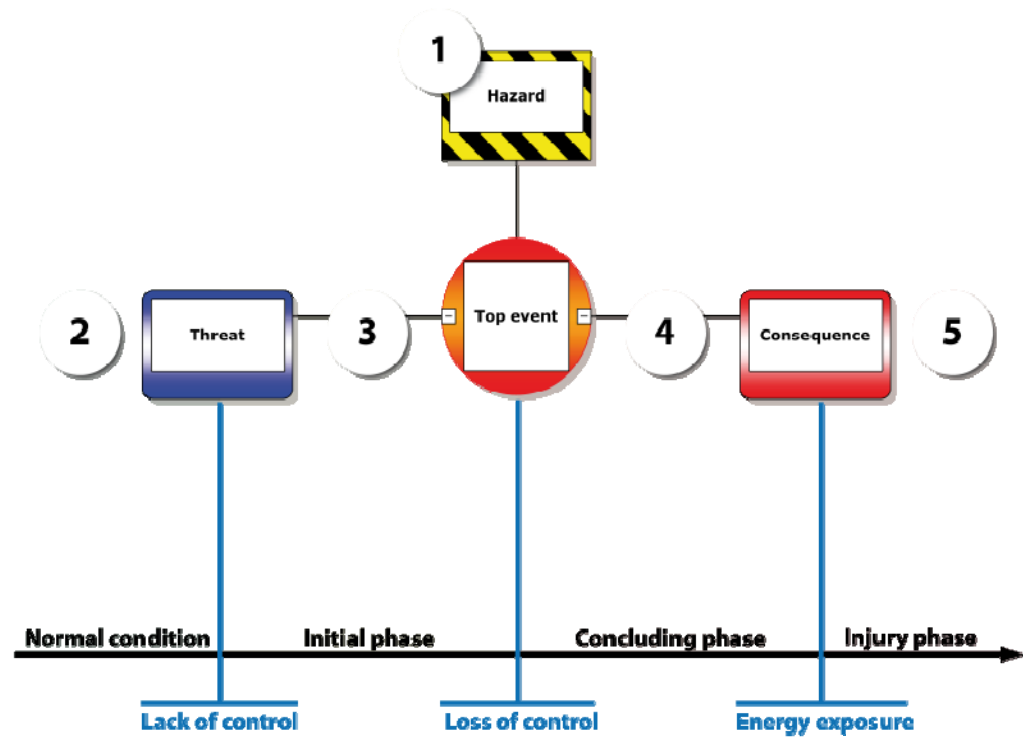


Measures taken to prevent or mitigate events

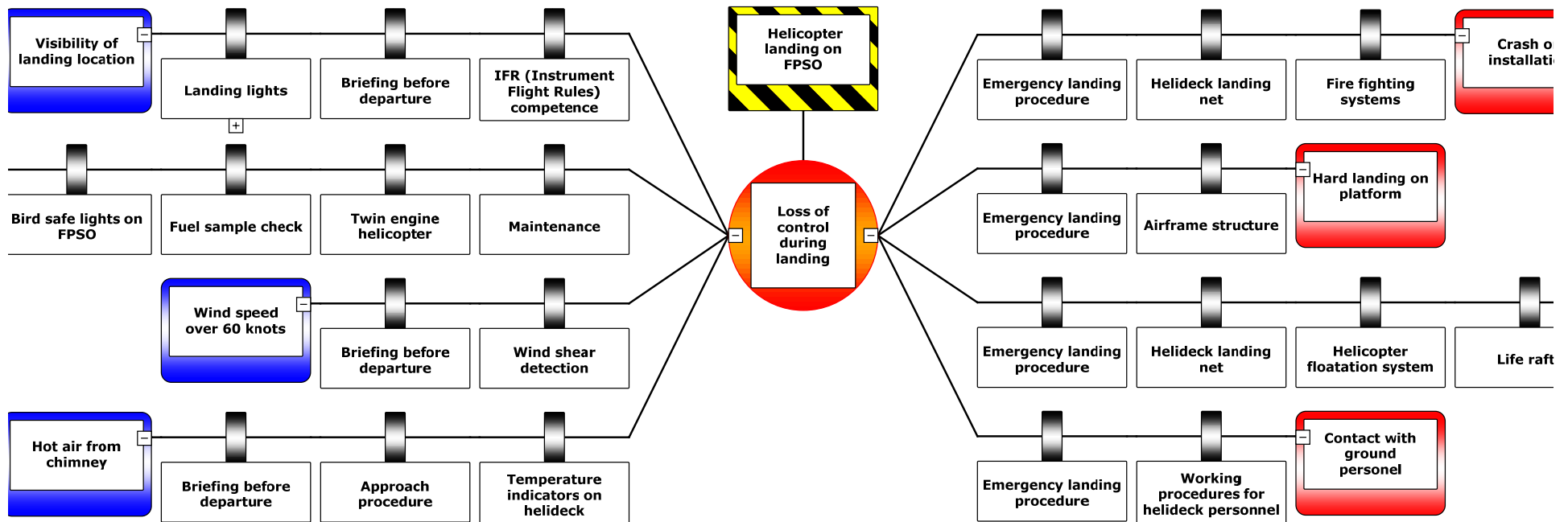
Barrier Function

Barrier Function

1. **Eliminate / Substitute** Hazard
2. **Eliminate** Threat
3. **Prevent** Top event
4. **Separate** Consequence
5. **Mitigate** Consequence



Barriers



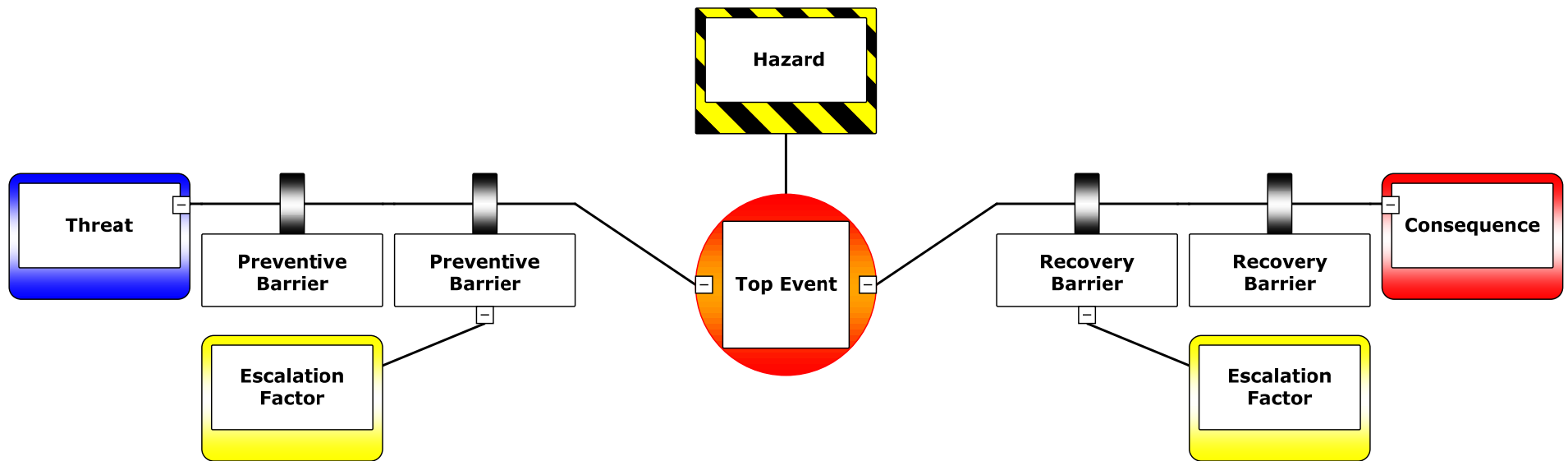
Step 7. Define Escalation Factors



Escalation
Factor

A condition that defeats or reduces the effectiveness of a Barrier

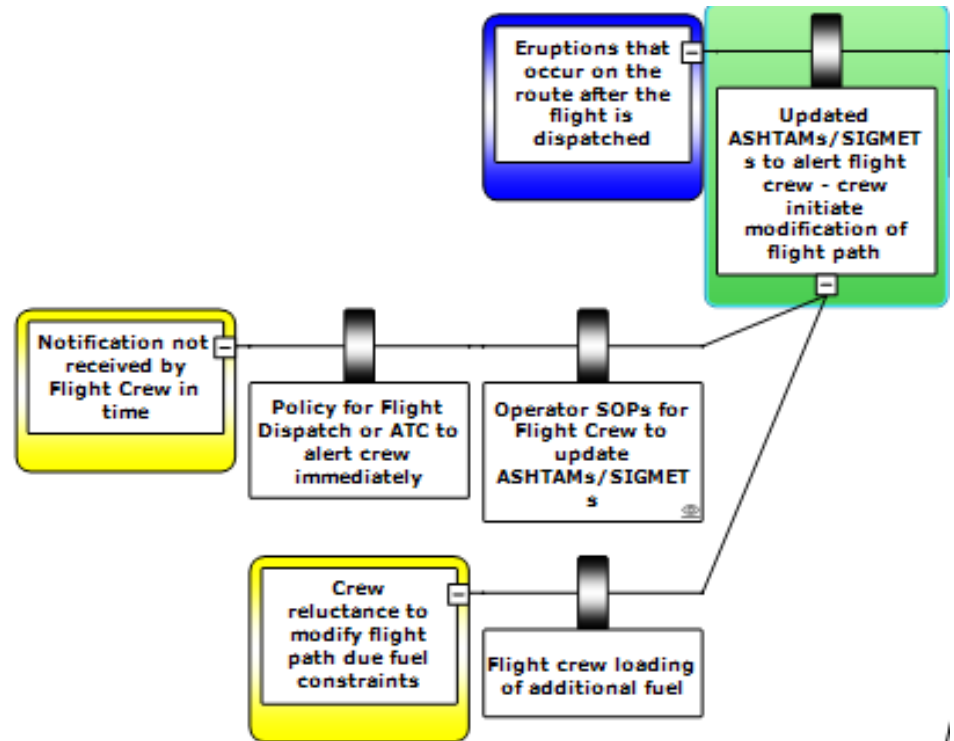
Escalation Factor



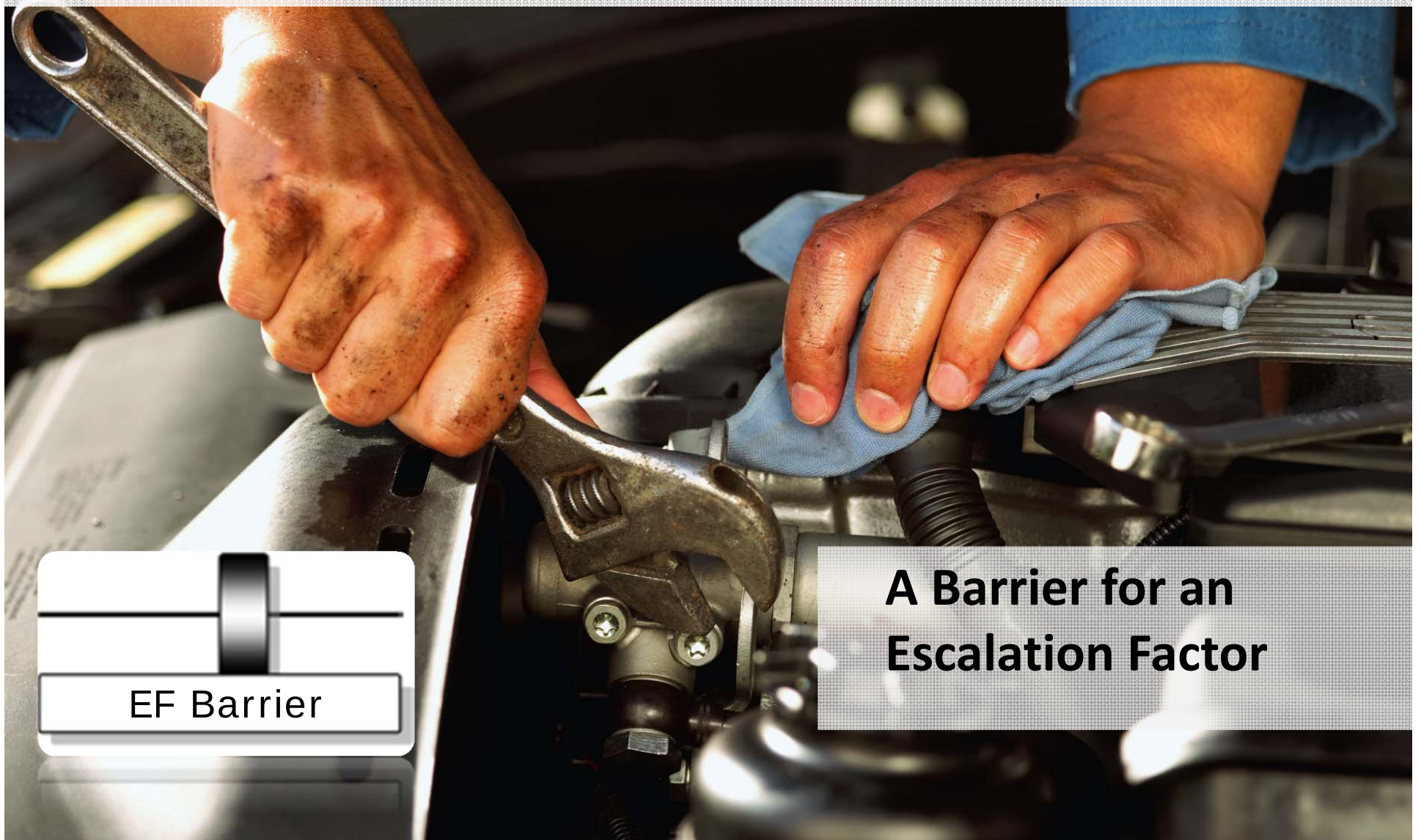
Four main categories

There are four main Escalation Factor categories:

- Human Factors
- Mechanical Failures
- Abnormal Conditions
- Loss of Critical Services



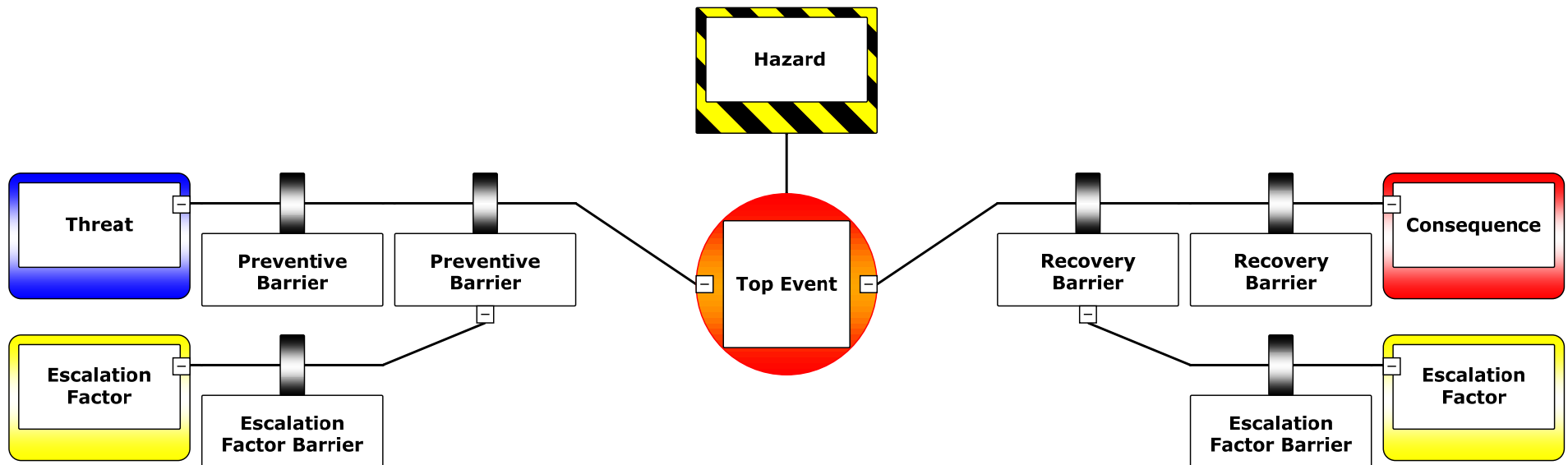
Step 8. Defining EF Barriers



**A Barrier for an
Escalation Factor**

EF Barrier

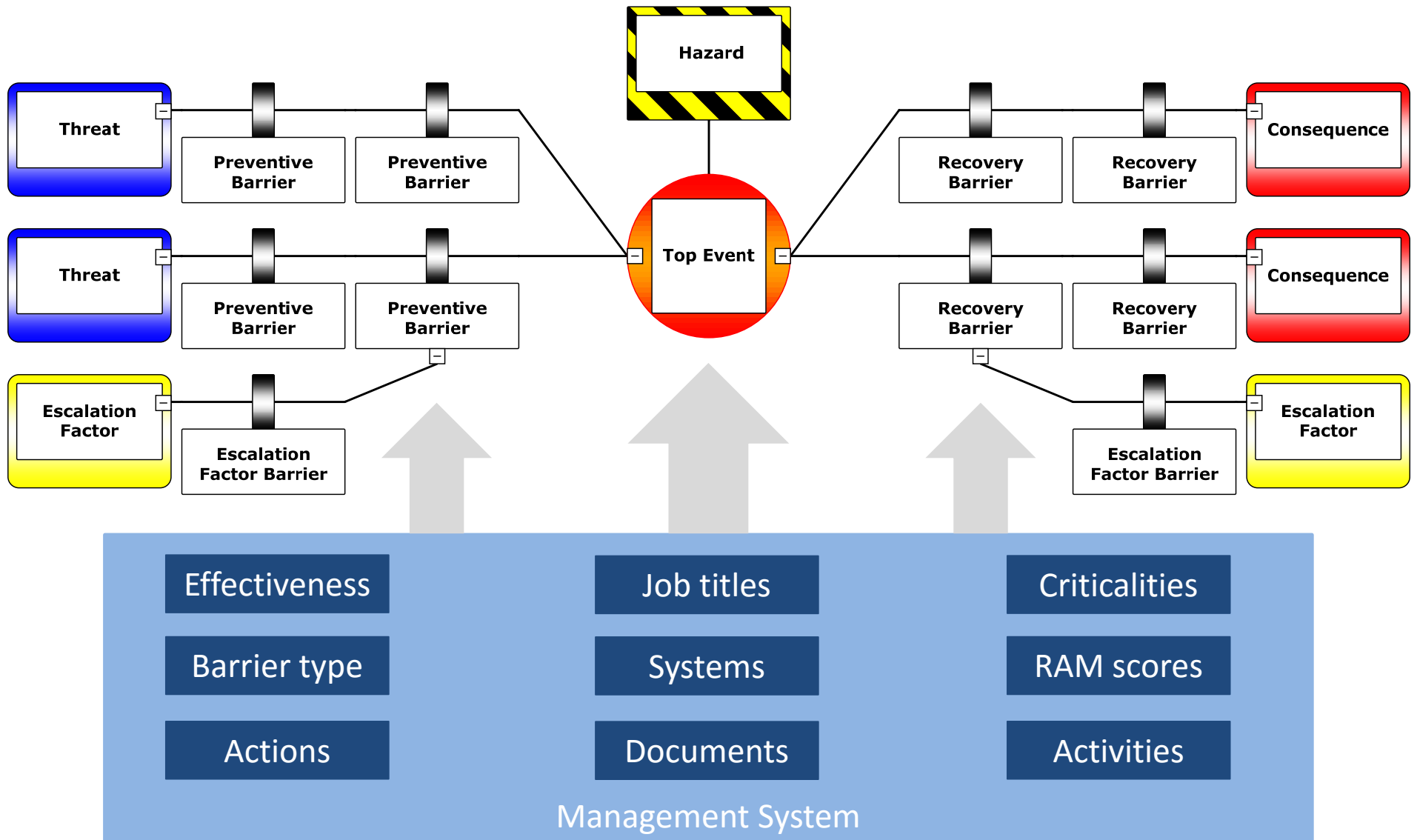
Escalation Factor Barrier



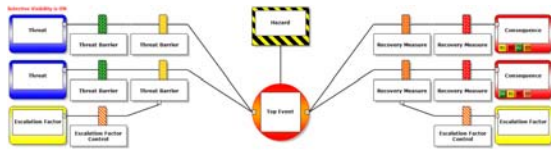
Exercise



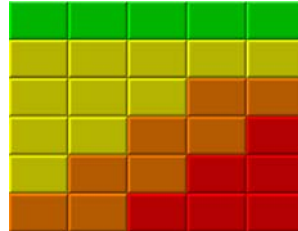
Basic BowTie diagram



What's in a .btf?



Bowtie Diagrams



Risk matrices

Threat or Cause
Control or Barrier

Terminology

Very poor
Poor
Unknown
Good
Very Good

Categories

W-1.2.01 : Contractor Selection
W-1.2.02 : Quality Checks
W-1.2.03 : Pressure Testing
FRM.02 : Approval Form
FRM.04 : Pressure Test Form
FRM.05 : Welding PTW

Management System

- Quantification models
- Incident analysis
- Operations (SOOB)

Advanced

Providing additional information

- Job Titles (Accountable person)

- Barrier Effectiveness

- Barrier Type

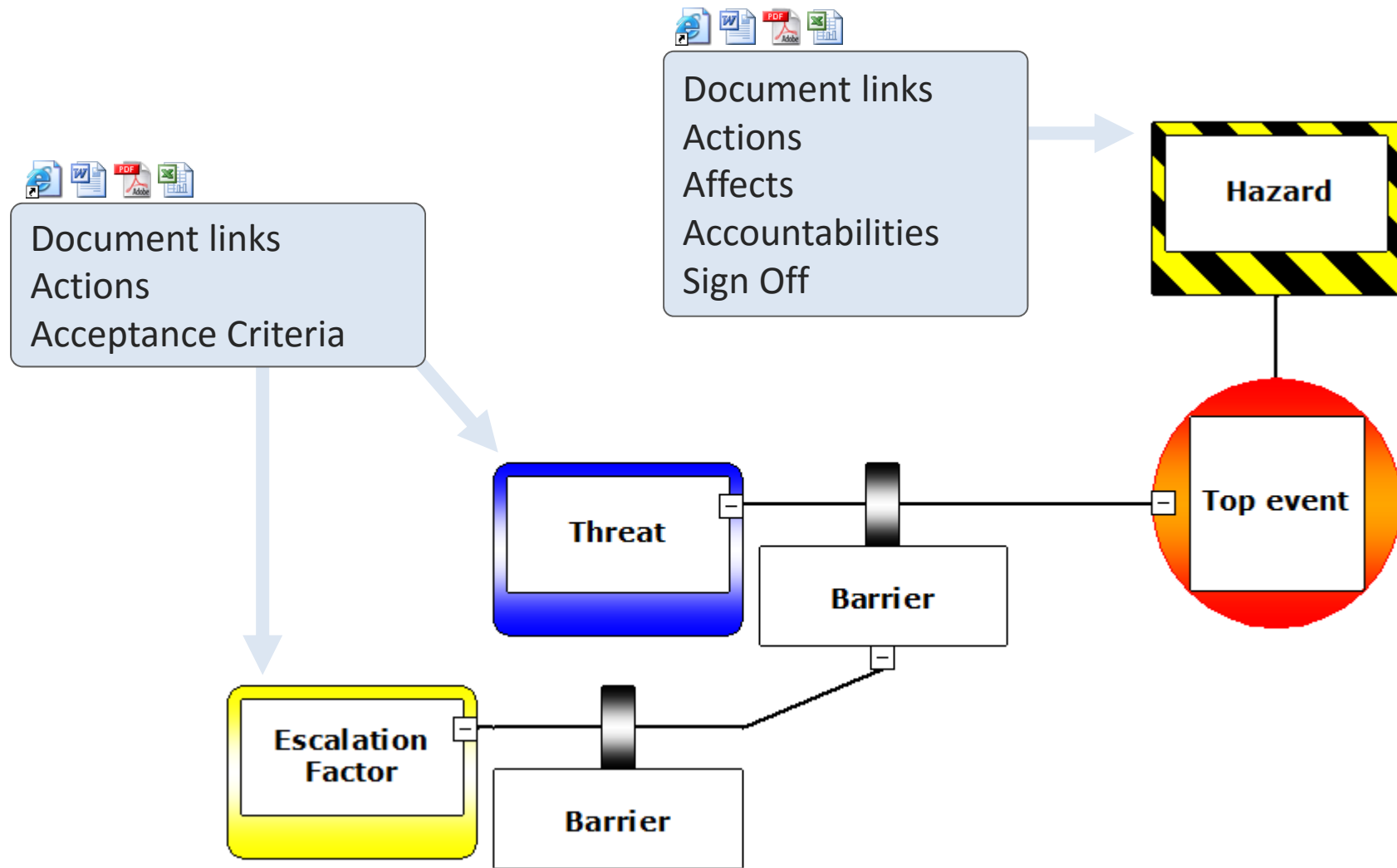
- Barrier criticality

- Activities

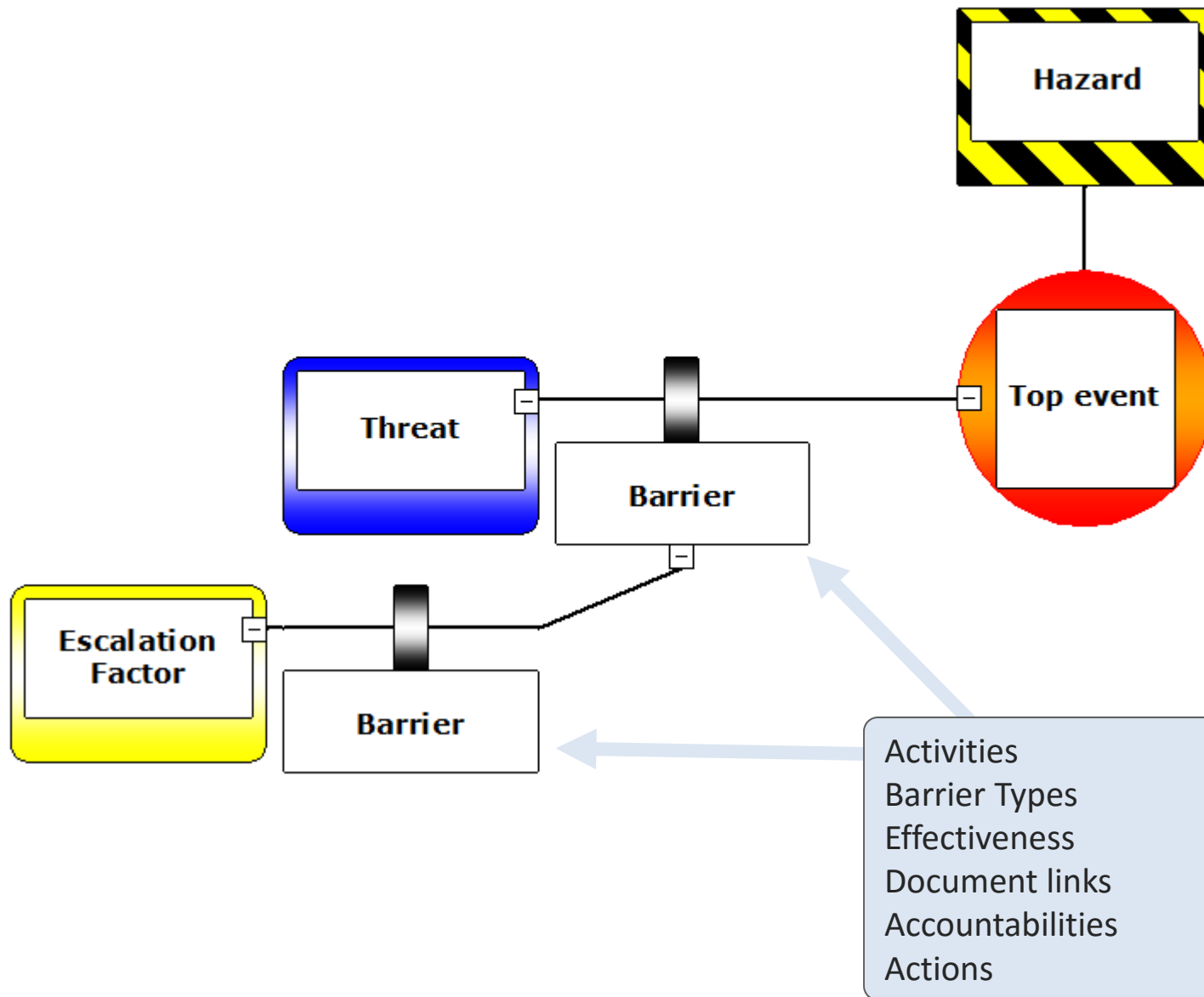
- Document Links

- Actions

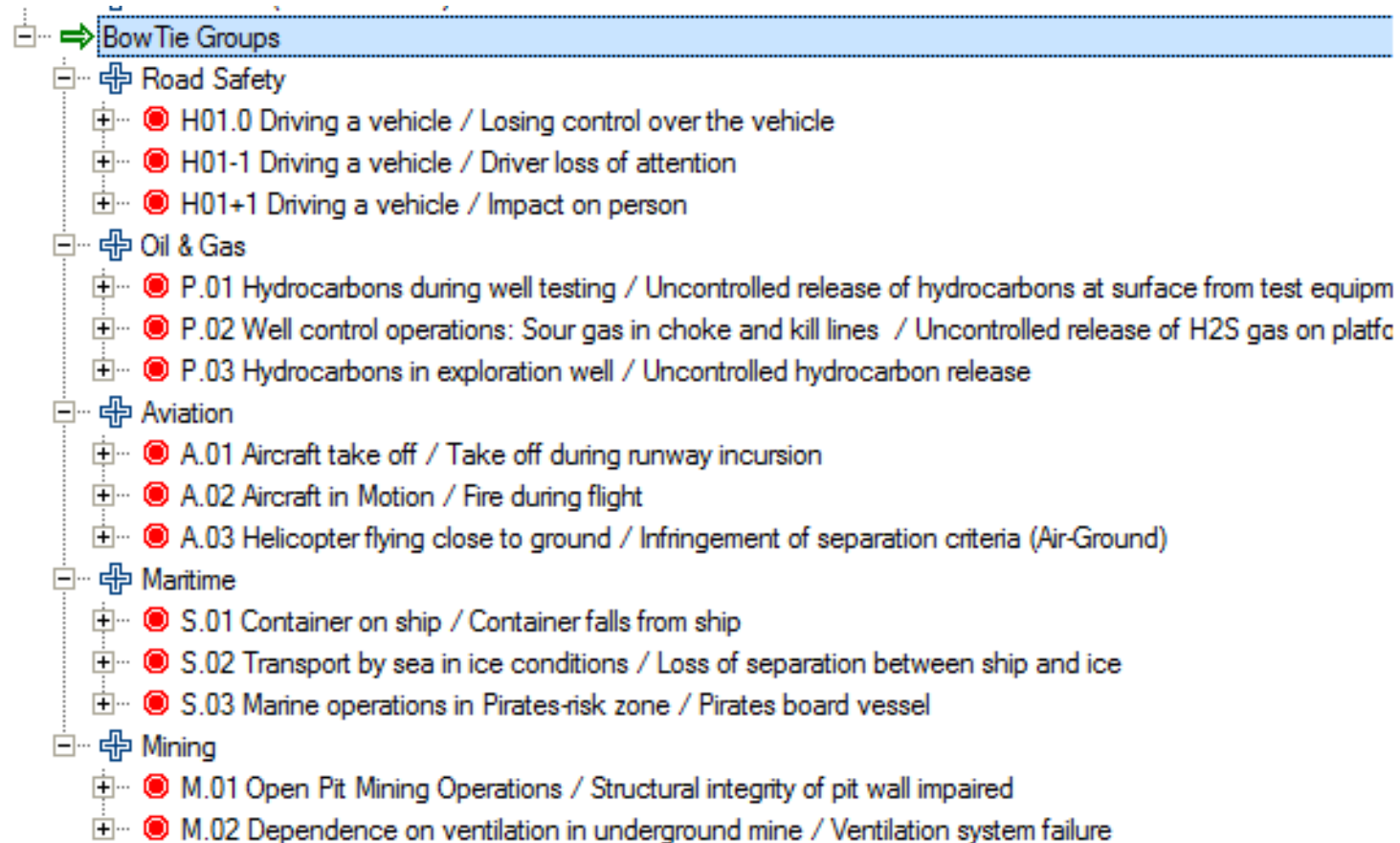
BowTieXP Metadata

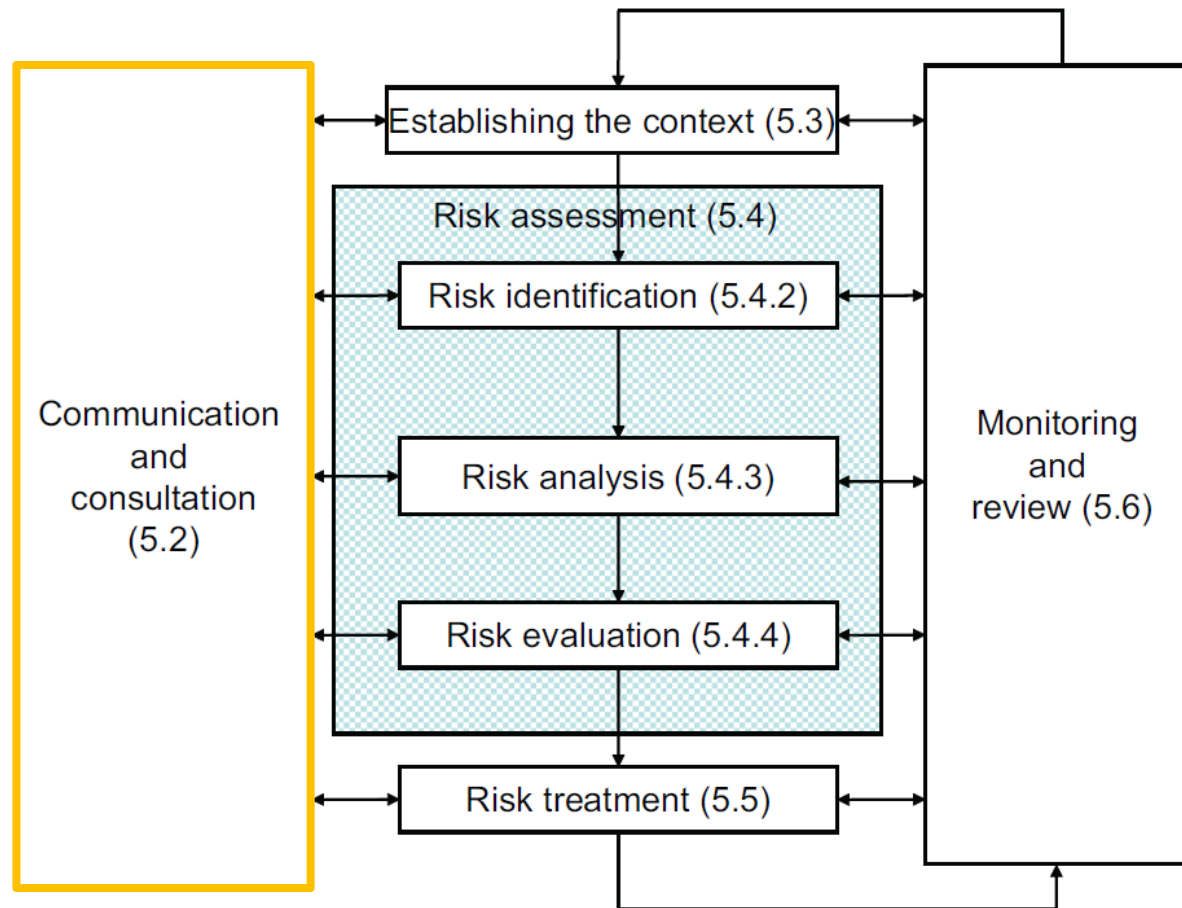


BowTieXP Metadata



Set of bowties, now what...?





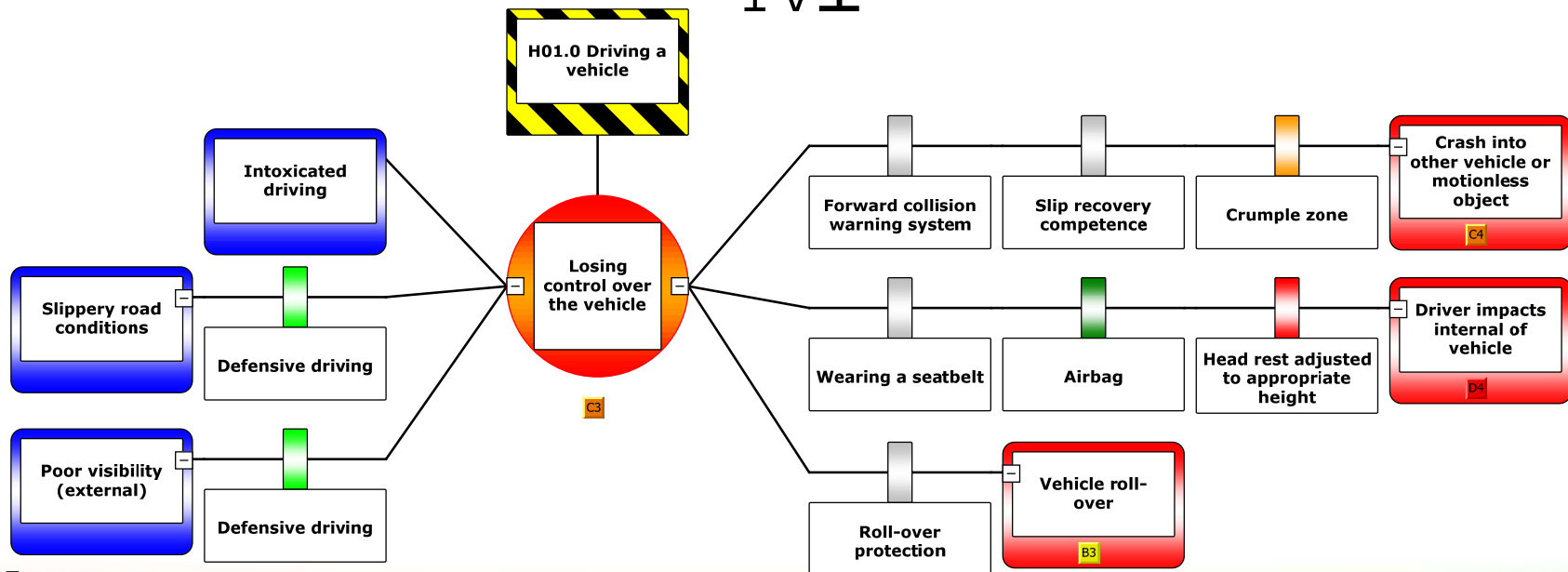
Communication and consultation

Communication and consultation with external and internal stakeholders should take place during all stages of the risk management process.

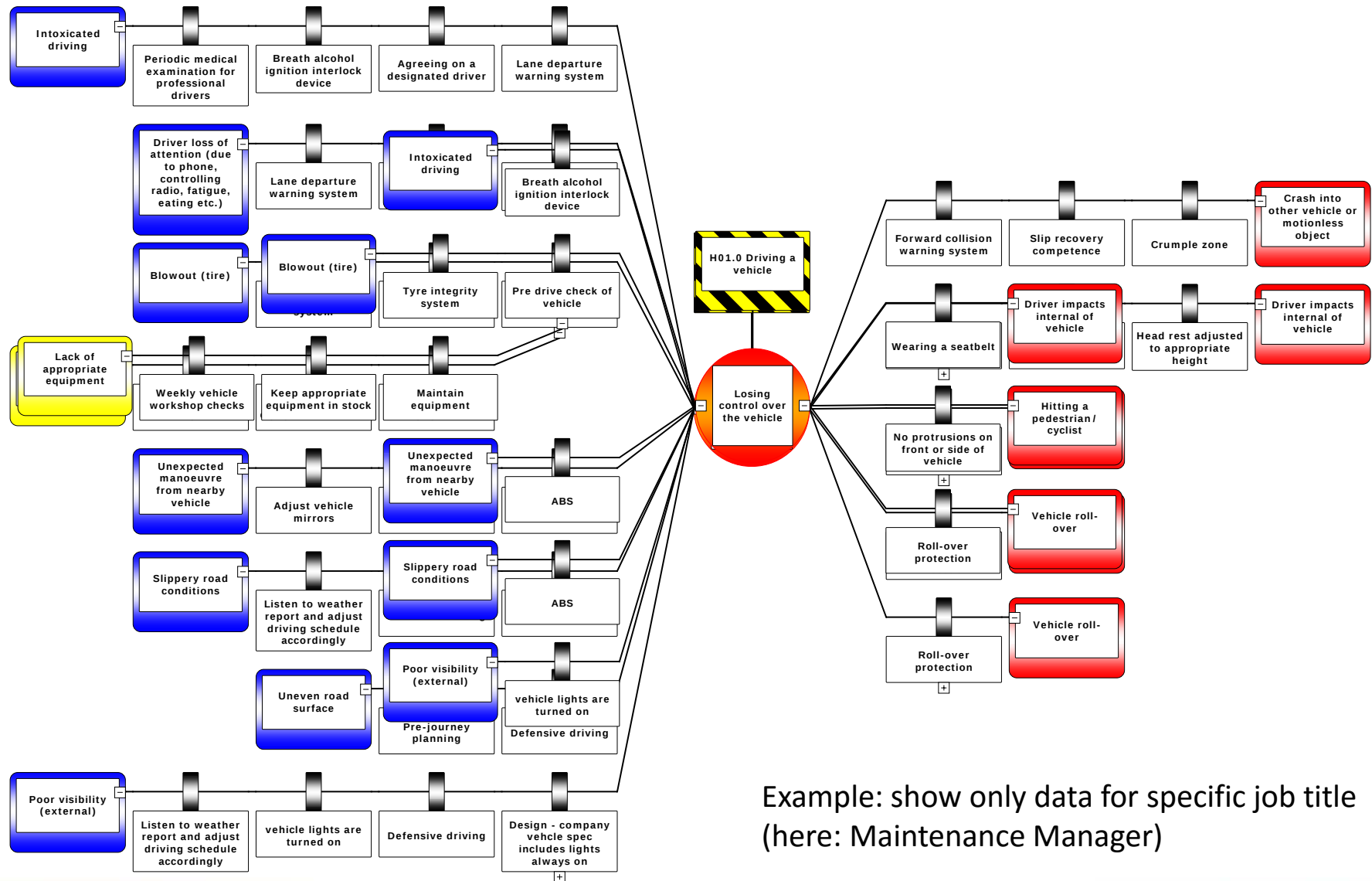
Communicating risks

	A	B	C	D	E
1	Risk	Threats	Consequences	Barriers	Risk level
2	Driving a car / Losing control over the car	Intoxicated driving Slippery road conditions Poor visibility (external)	Crash into other car or motionless object Driver impacts Internal of car Vehicle roll-over	Airbag Crumple zone Defensive driving procedure Forward Collision Warning System Head rest adjustment to appropriate height Roll-over protection Seatbelt Slip recovery competence	Med

yv1

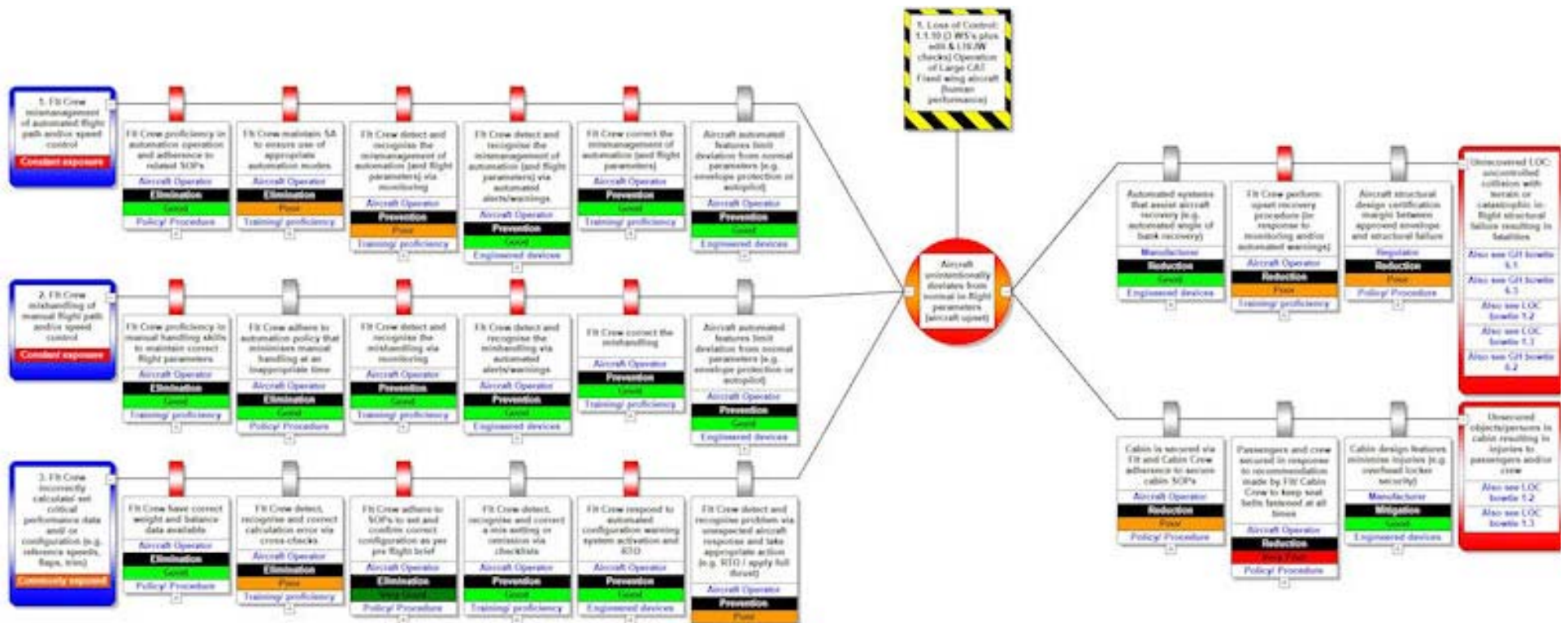


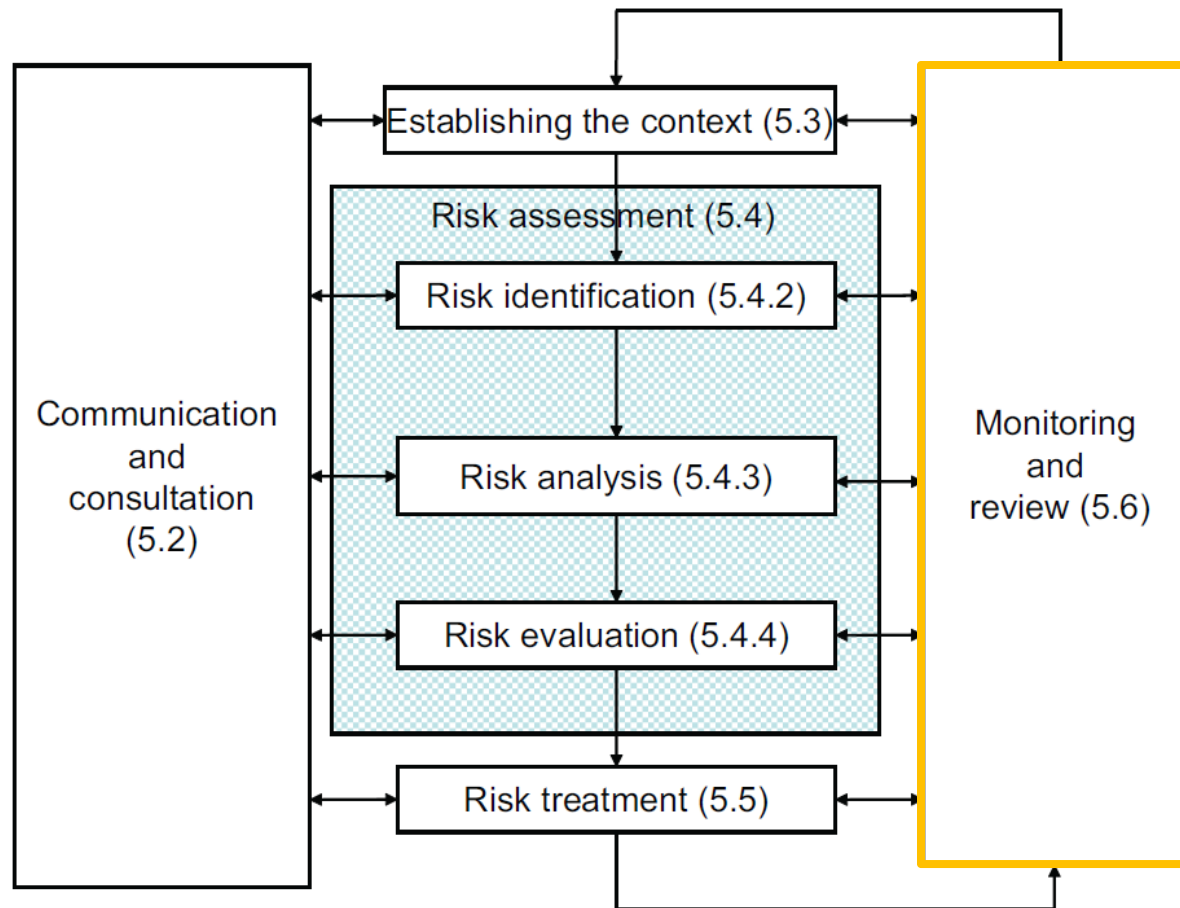
Easy data filtering on the diagram



Example: show only data for specific job title
(here: Maintenance Manager)

Safety improvements





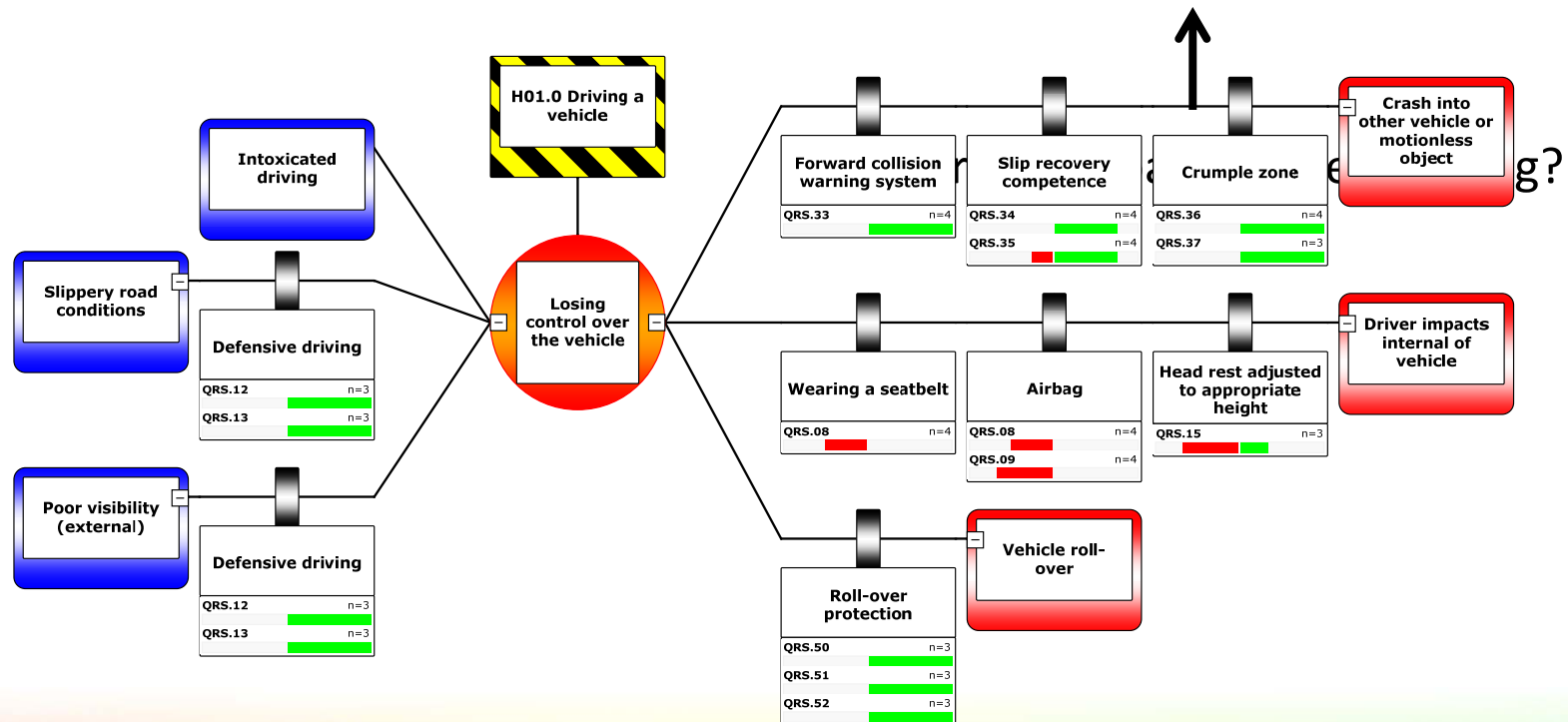
Monitoring and review

Risk based auditing with

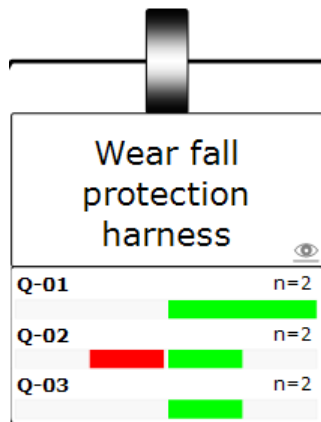


Monitoring and review

	A	B	C	D	E
1	Risk	Threats	Consequences	Barriers	Risk level
2	Driving a car / Losing control over the car	Intoxicated driving Slippery road conditions Poor visibility (external)	Crash into other car or motionless object Driver impacts Internal of car Vehicle roll-over	Airbag Crumple zone Defensive driving procedure Forward Collision Warning System Head rest adjustment to appropriate height Roll-over protection Seatbelt Slip recovery competence	Med



Barrier-based Audits



Q01: (Stock keeping)

"Are the fall protection materials available at the site?"

Q02: (Training)

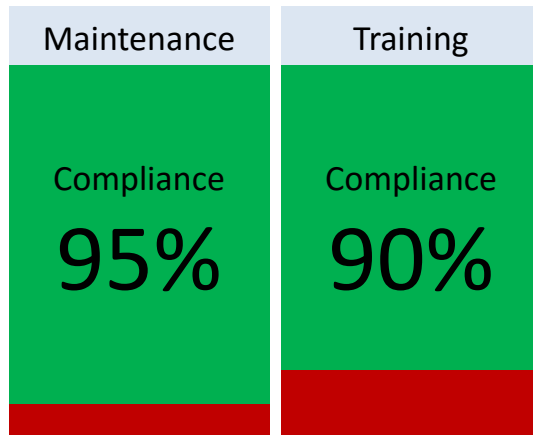
"Is the personnel competent in the use of the harness?"

Q03: (Procedures)

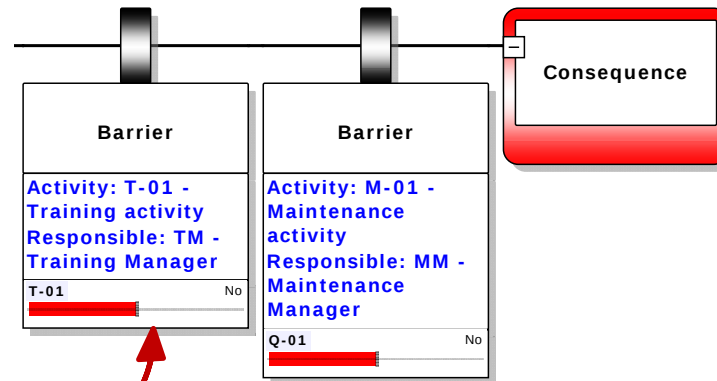
"Does the personnel know for which tasks the harness must be used?"

Audit approaches

Traditional

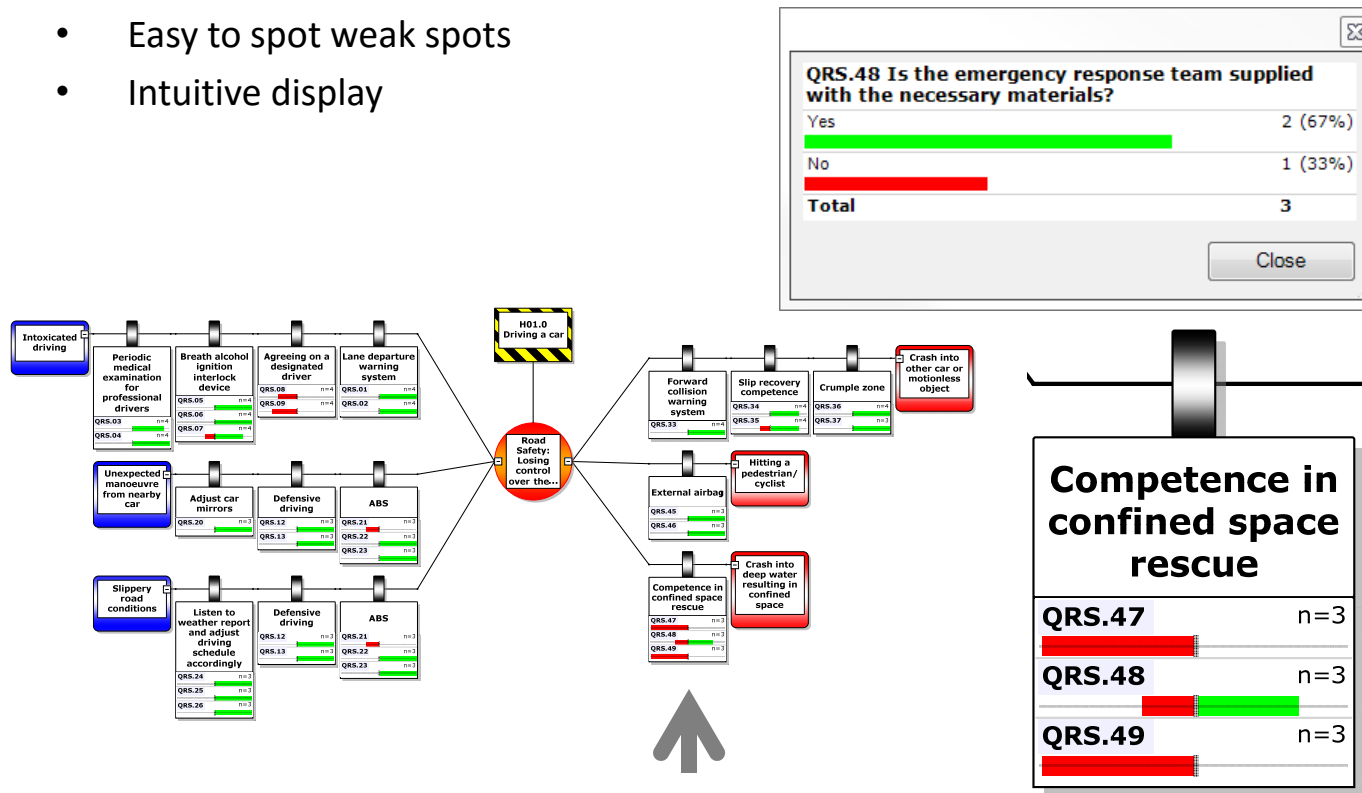


Barrier-based



Visual results

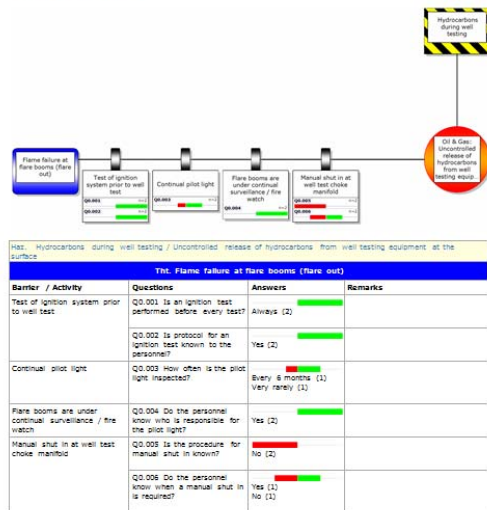
- Easy to spot weak spots
- Intuitive display



Audit reports

Case: 'United' - Report: 'Survey results shown on barriers'

Hydrocarbons during well testing / Uncontrolled release of hydrocarbons from well testing equipment at the surface

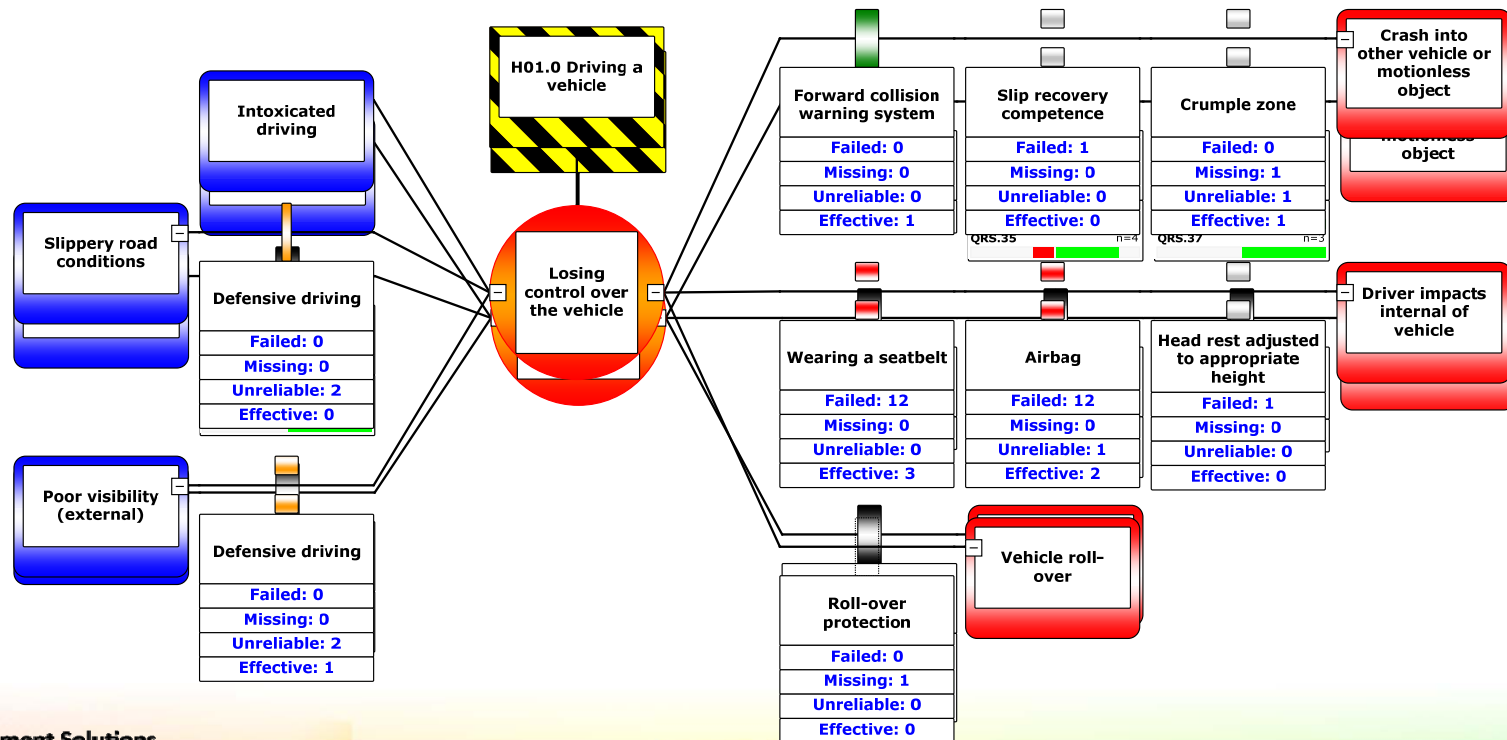


7 aug 2013

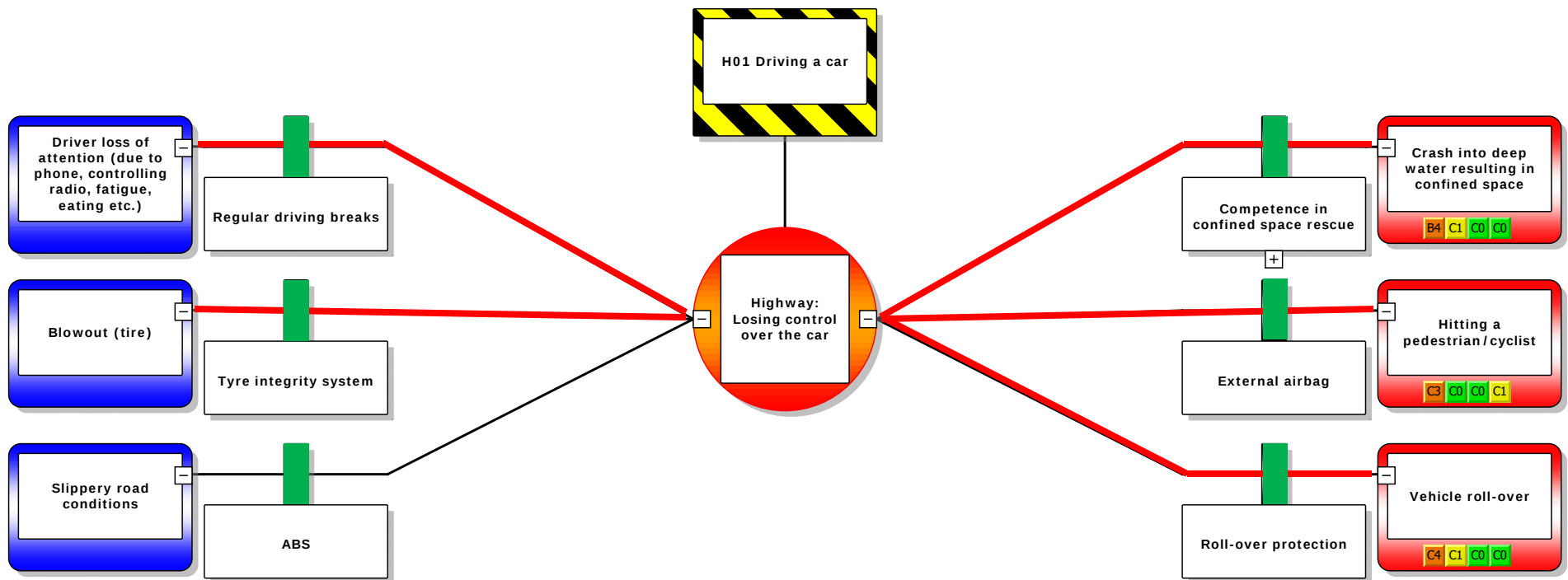
5 / 11

Monitoring and review

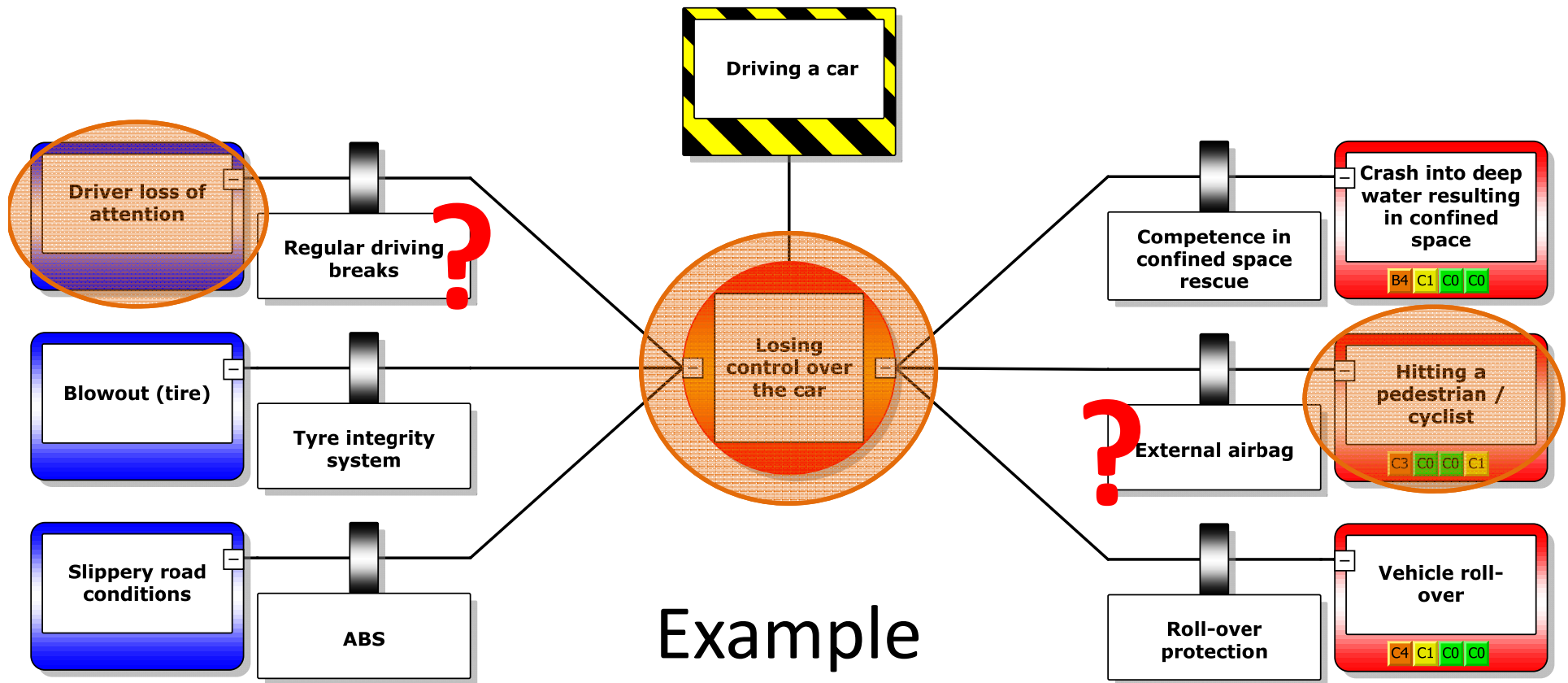
	A	B	C	D	E
1	Risk	Threats	Consequences	Barriers	Risk level
2	Driving a car / Losing control over the car	Intoxicated driving Slippery road conditions Poor visibility (external)	Crash into other car or motionless object Driver impacts Internal of car Vehicle roll-over	Airbag Crumple zone Defensive driving procedure Forward Collision Warning System Head rest adjustment to appropriate height Roll-over protection Seatbelt Slip recovery competence	Med



BSCAT from BowTie



BowTieXP provides input



Example

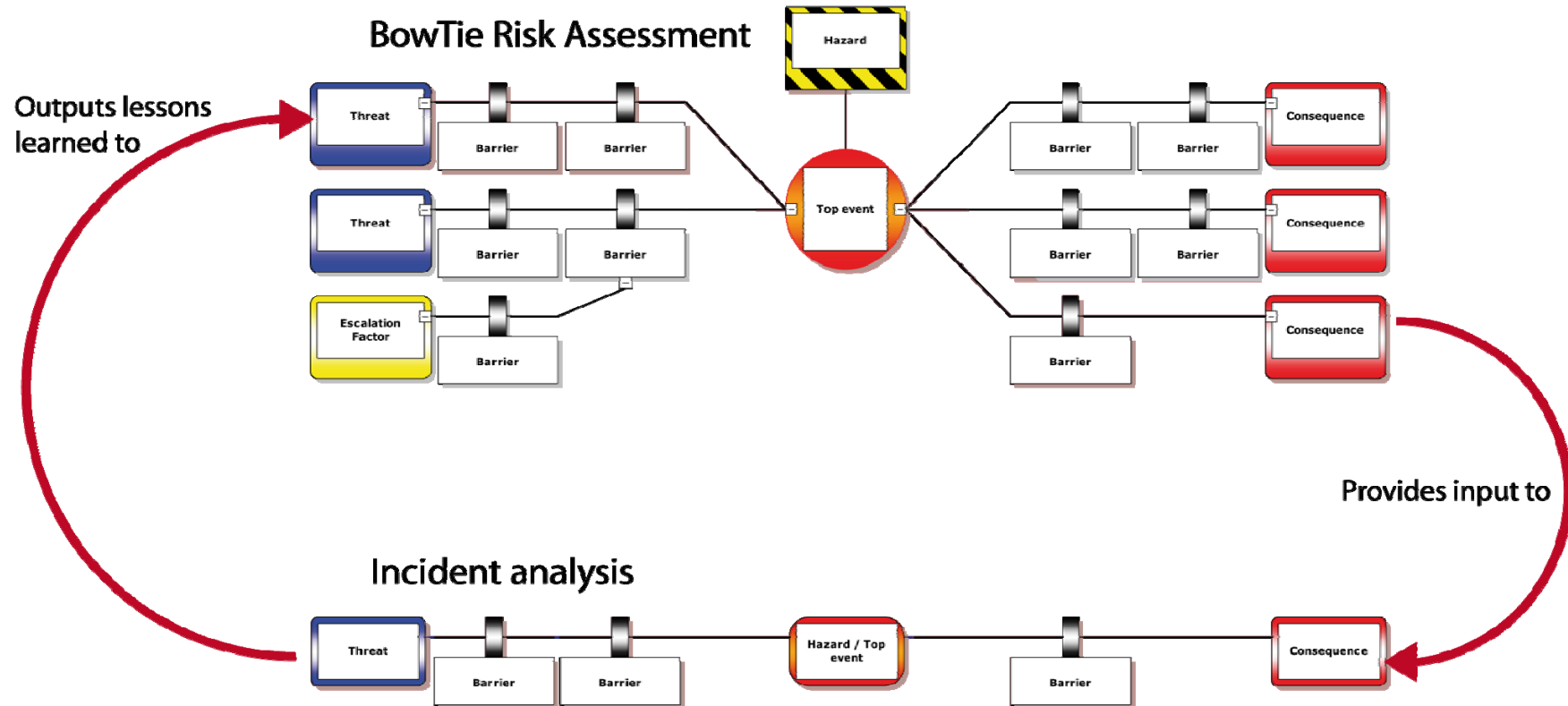
Incident analysis with



BSCAT | Tripod Beta | BFA | RCA



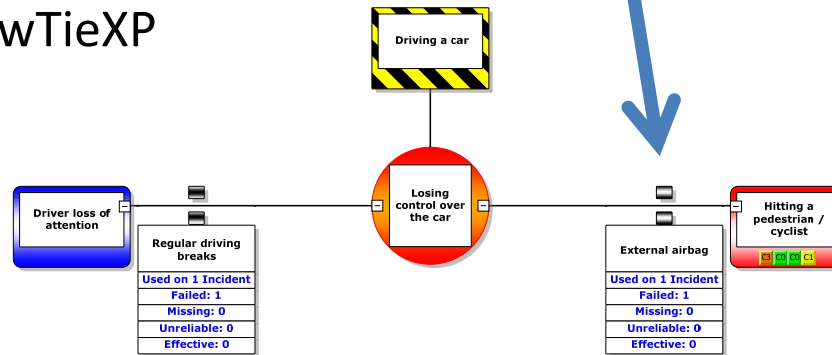
Incidents



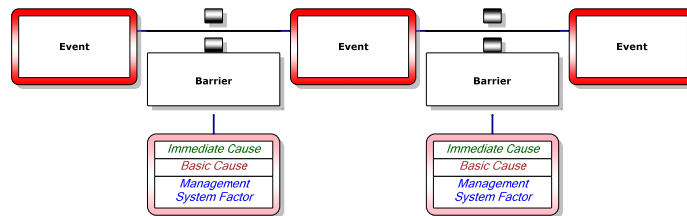


IncidentXP

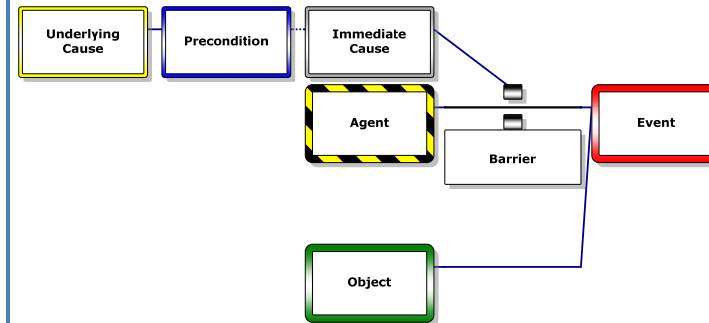
BowTieXP



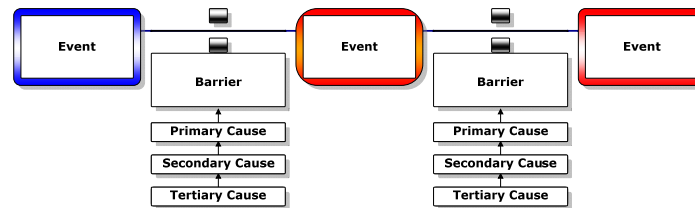
BSCAT



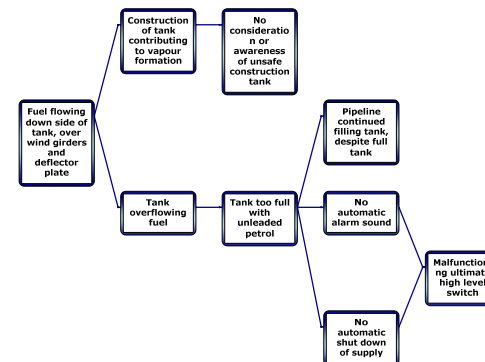
Tripod Beta



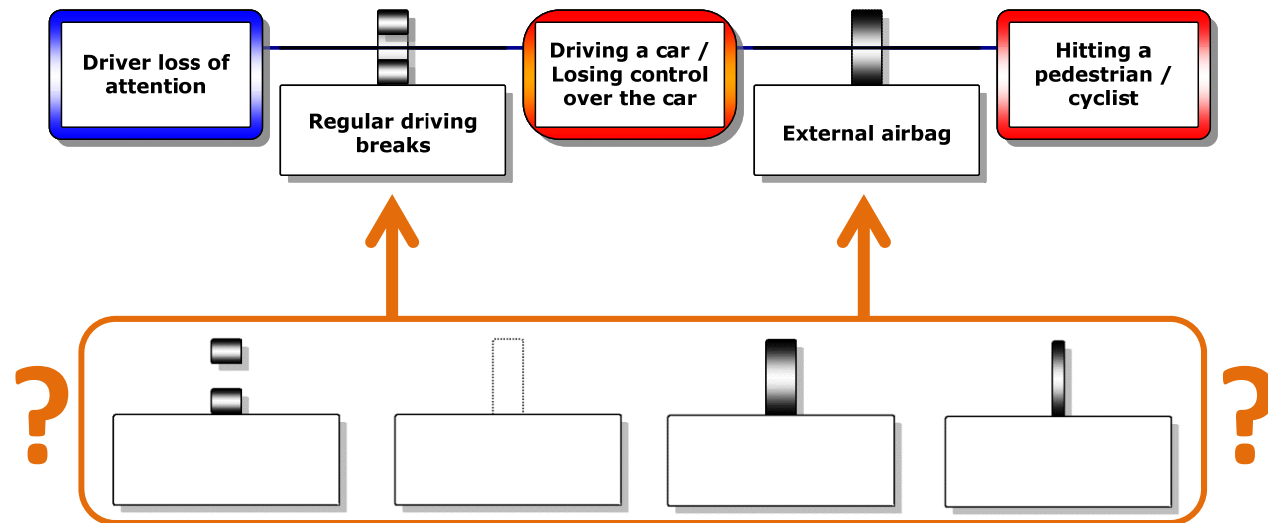
Barrier Failure Analysis



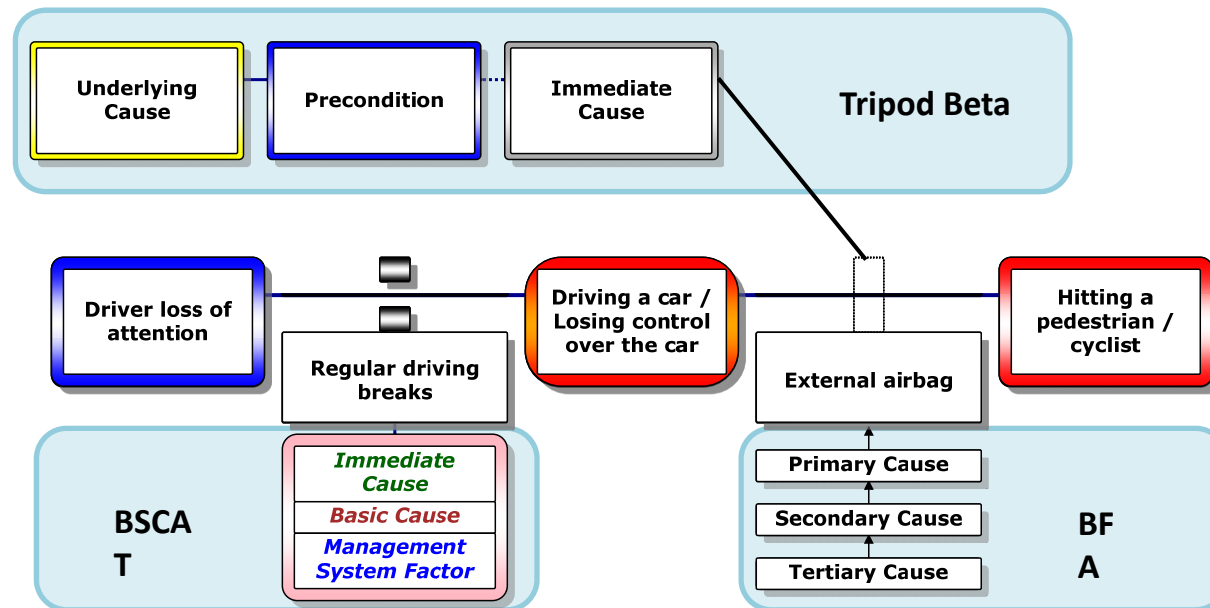
Root Cause Analysis



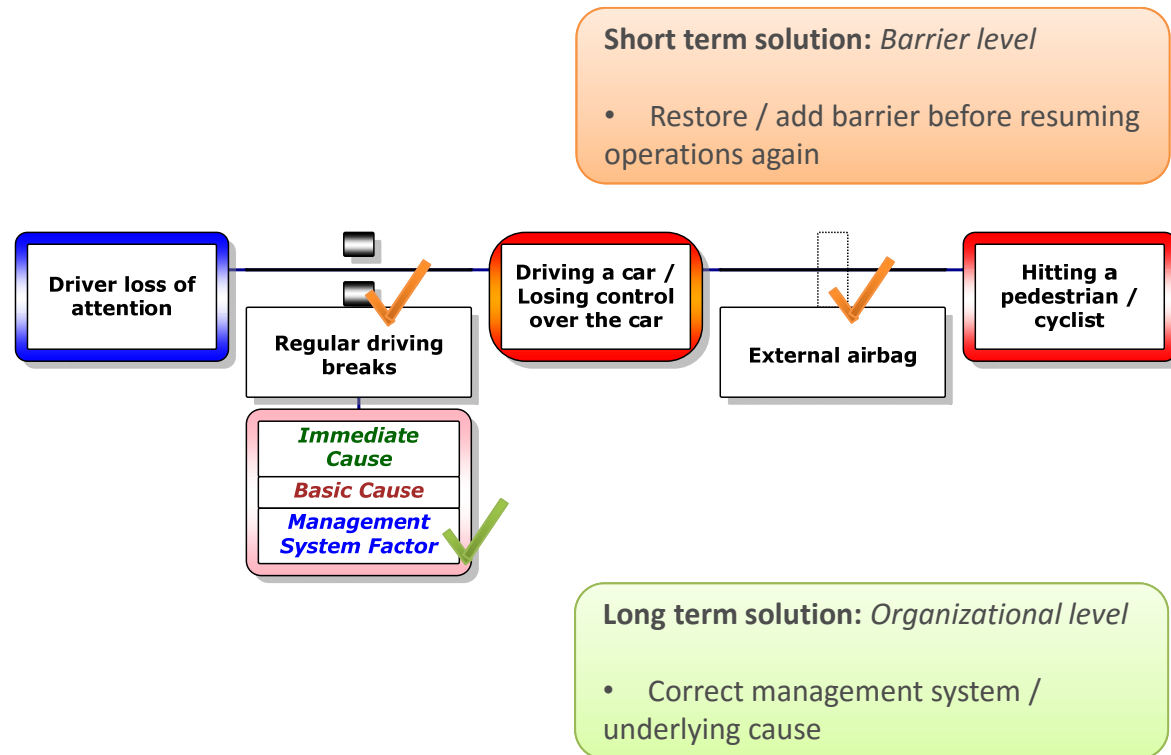
Barrier Failure



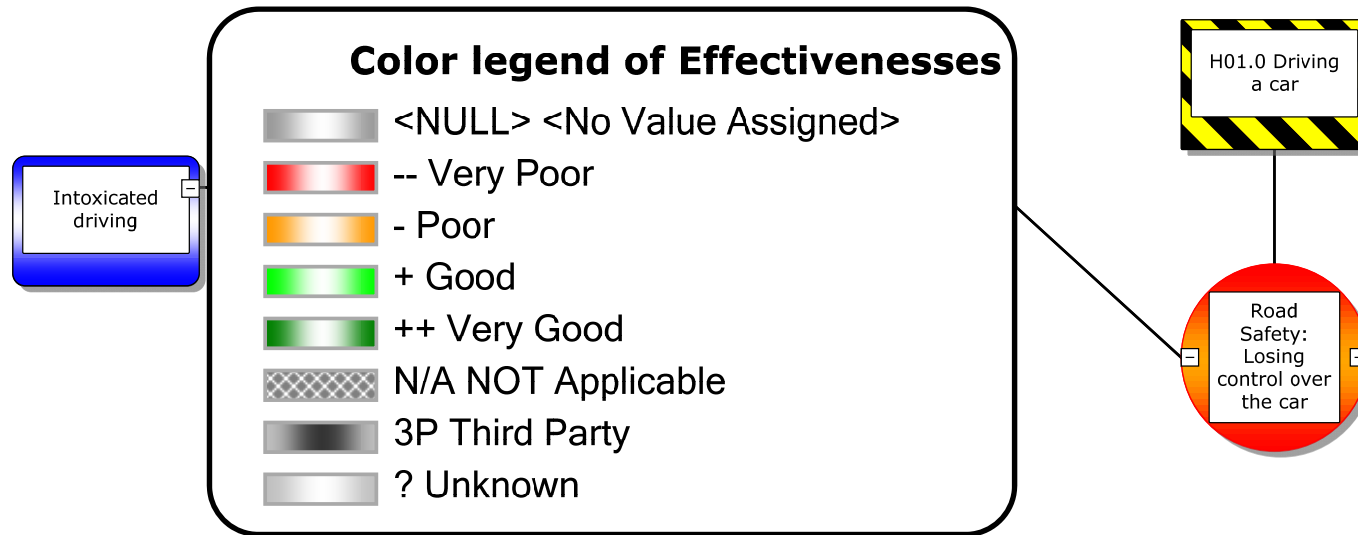
Causation Paths



Recommendations

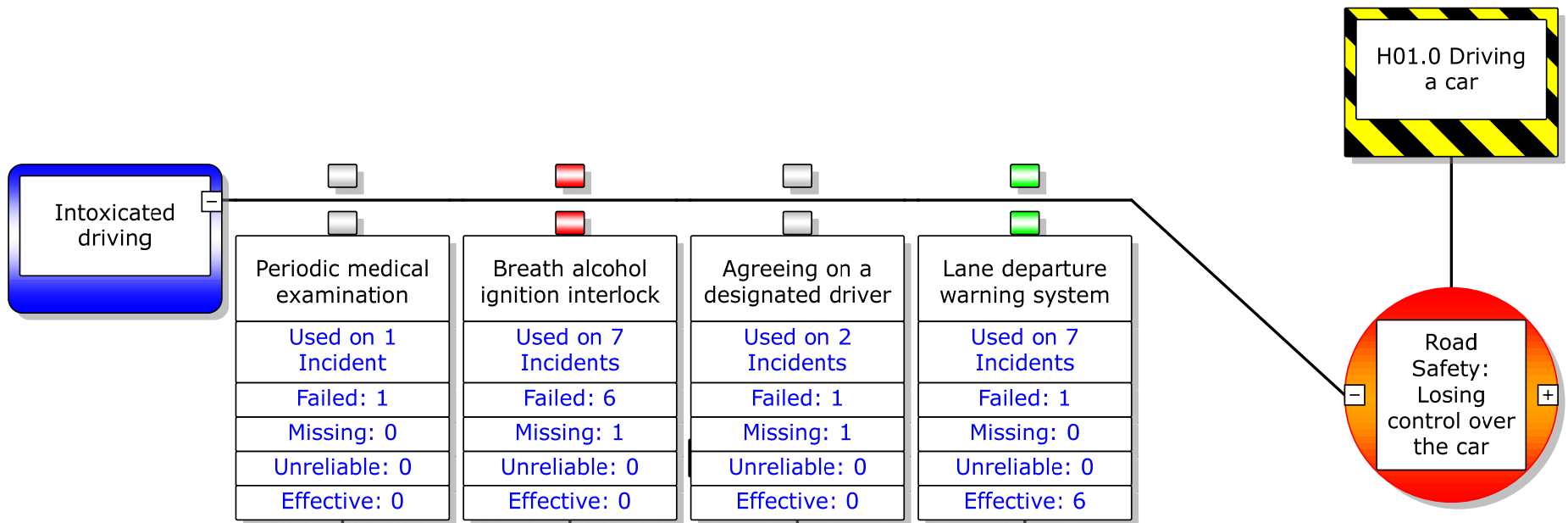


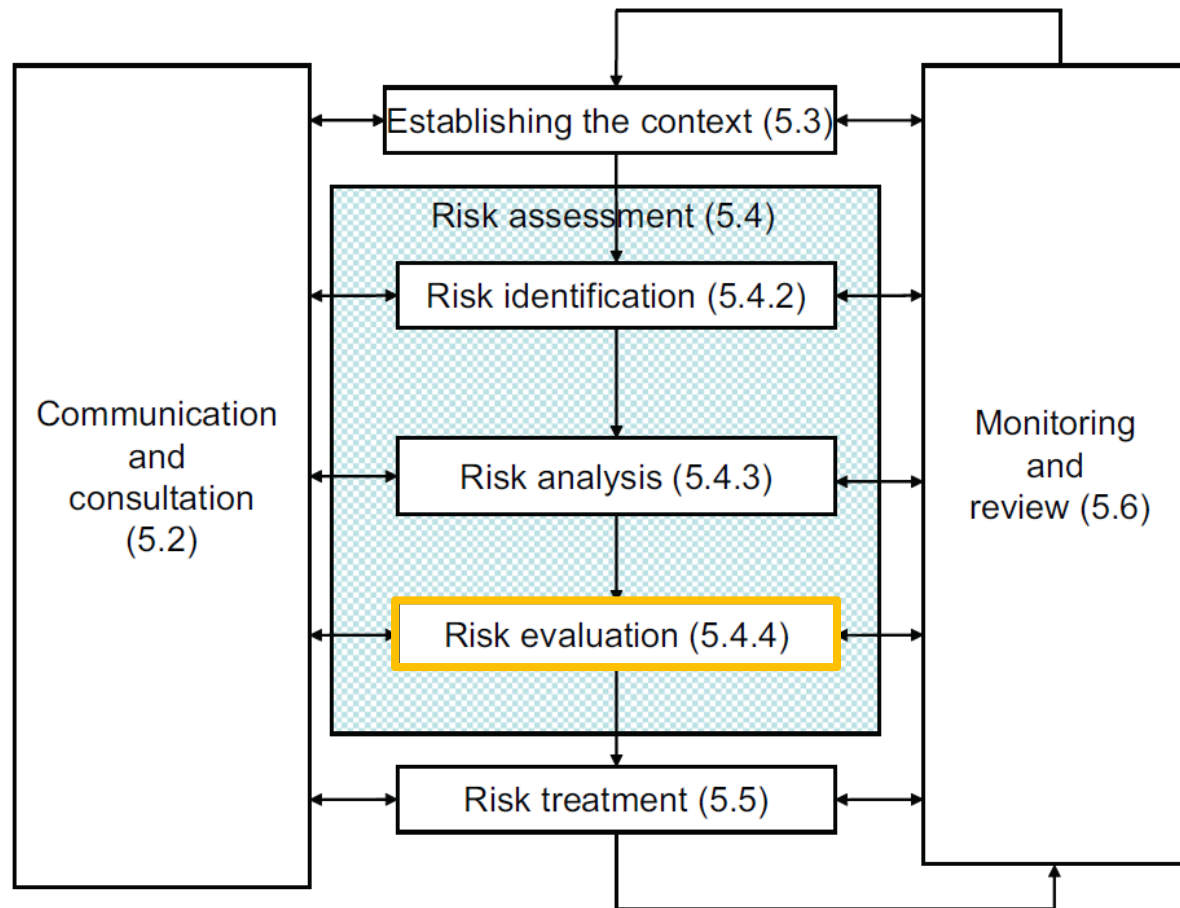
IncidentXP provides feedback



Example

IncidentXP provides feedback on Bowtie diagram





Risk evaluation

to assist in making decisions,[..] about **which risks need treatment** and the **priority** for treatment implementation.

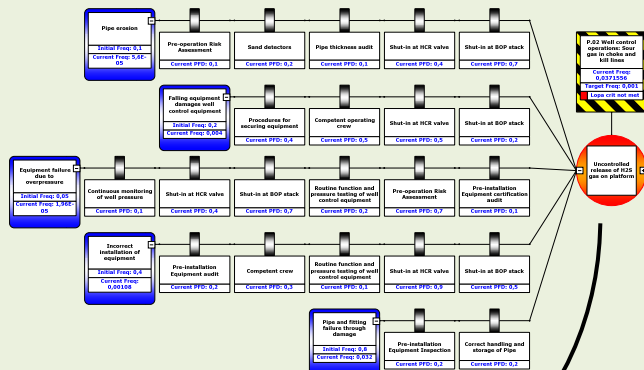
Quantify your bowtie diagram with the

Layers Of Protection Analysis (LOPA) Plug-in



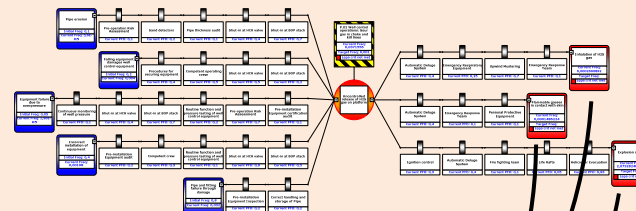
LOPA Approach

Only left side



Acceptance criteria for the Top Event

Whole bowtie diagram



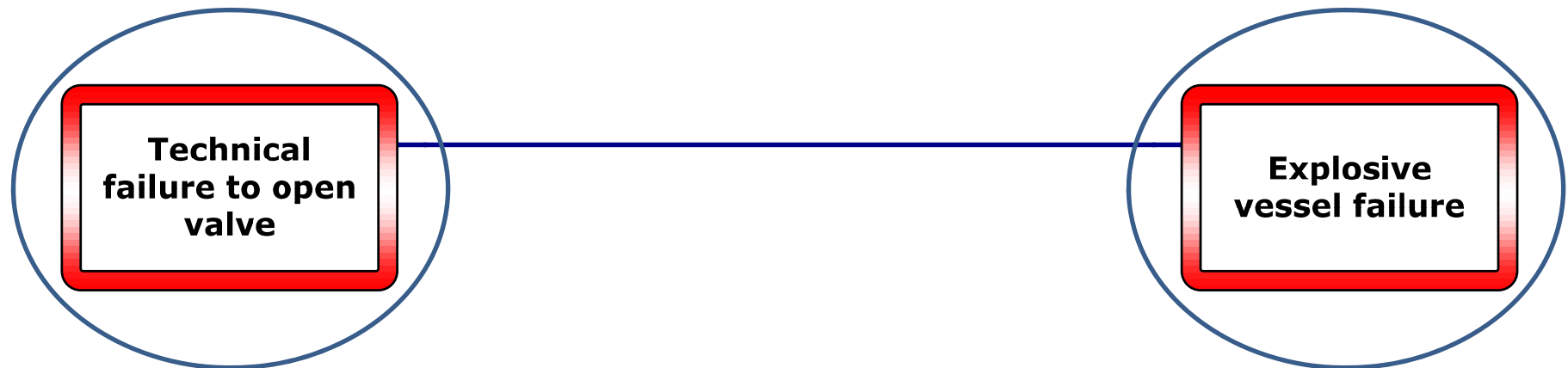
Acceptance criteria per Consequence

Classical LOPA start

- Select a incident scenario
- Set a target frequency for the consequence
- Set a initial frequency of the initiating event

How likely is this to happen?
 $P(if)=0.2$

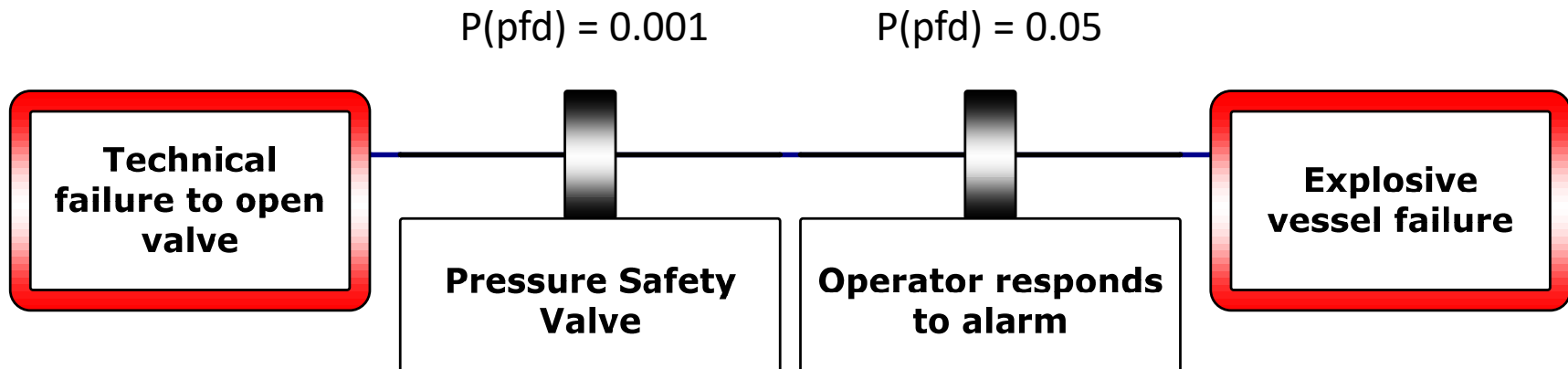
How acceptable is this?
 $P(tf)=0.0001$



Independent Protection Layer

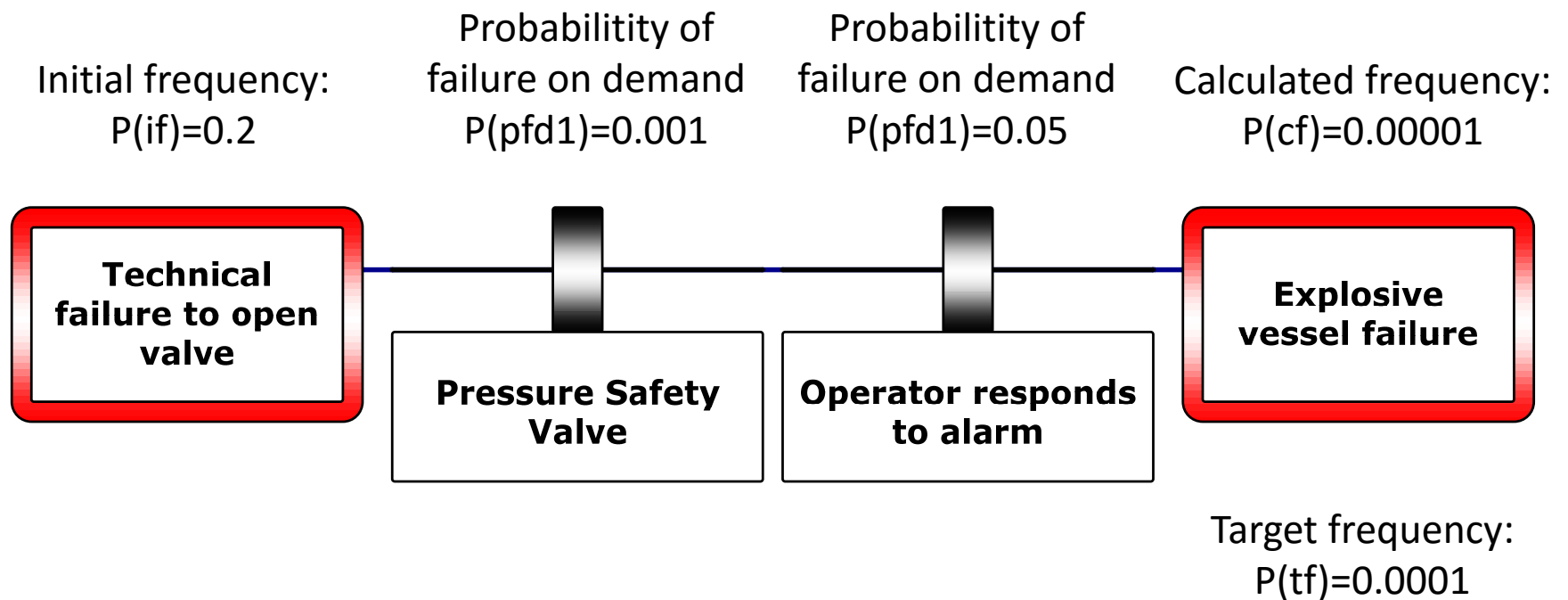
- Identify IPL's (i.e. barriers)
- Set Probability of Failure on Demand (PFD)

How likely will these fail?



Calculate

- Multiply the values to calculate the estimate
- Compare target with estimate: $P(cf) < P(tf)$



LOPA plug-in

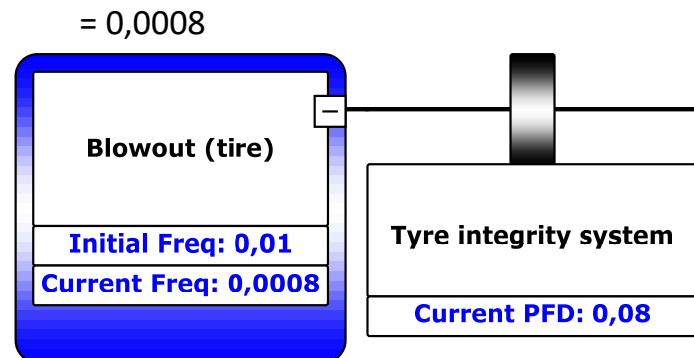
Initial frequency (IF) = Chance on threat being present

PFD = Probability of Failure on Demand

Current frequency = Chance of threat leading to the top event
= Initial frequency $\times$ PFD¹ $\times$ PFD² $\times$ PFD³ $\times$

(...)

Example below = 0,01 $\times$ 0,08



LOPA plug-in

Current frequency

TE

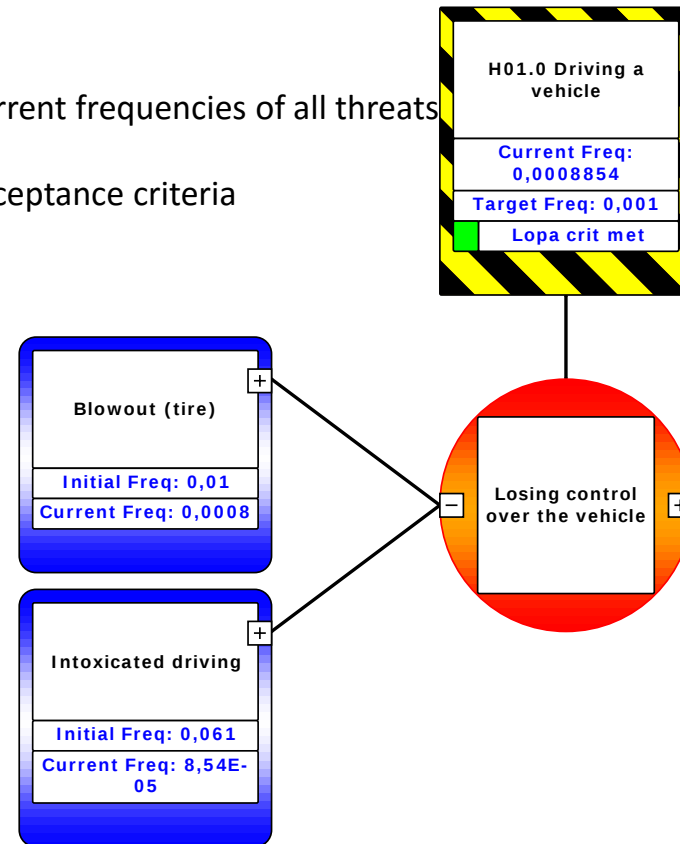
= Current frequencies of all threats

Target frequency

= Acceptance criteria

$$0,0008 + 8,54 \text{ E}^{-05} = 0,0008854$$

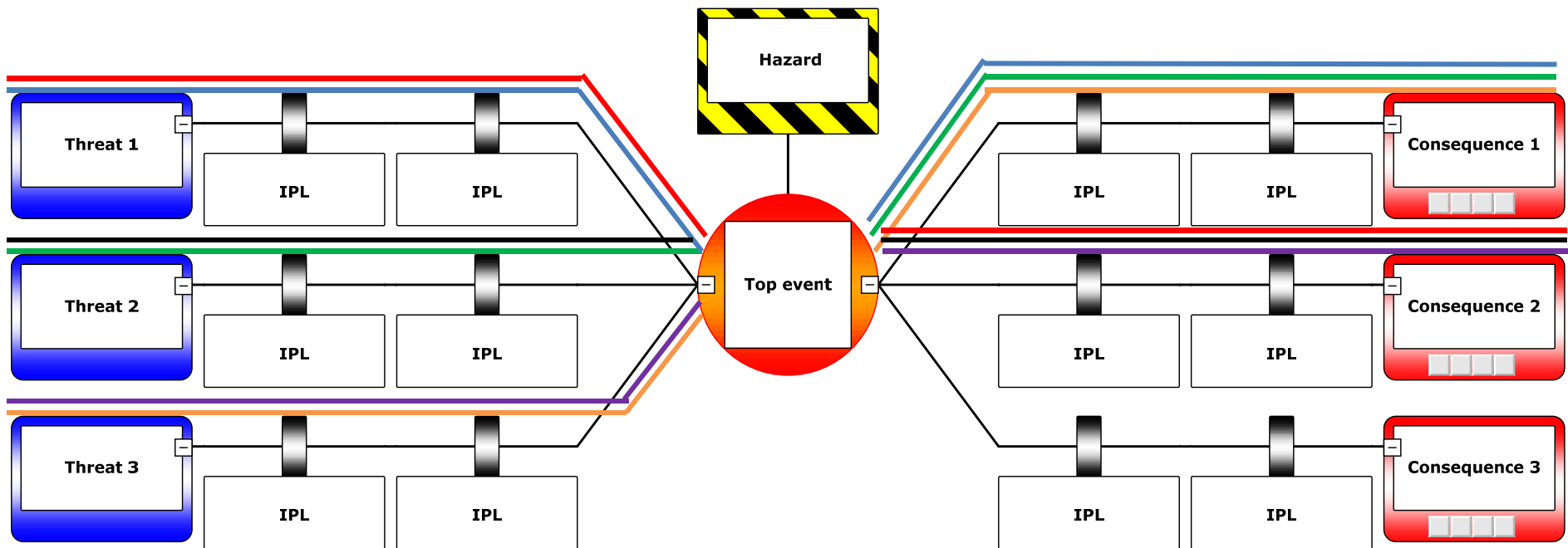
$$0,0008854 < 0,001 = \text{LOPA criteria met}$$



BowTies and LOPA?

- Different level of detail
- Barriers $\neq$ IPL
- BowTie knows only barriers
- Two models:
 - “Traditional”
 - “BowTie adapted”

BowTie and LOPA: “Traditional”



Generates individual scenario combinations(lines):

Thr. 1 – Cons. 1

Thr. 1 – Cons. 2

Thr. 1 – Cons. 3

Thr. 2 – Cons. 1

Thr. 2 – Cons. 2

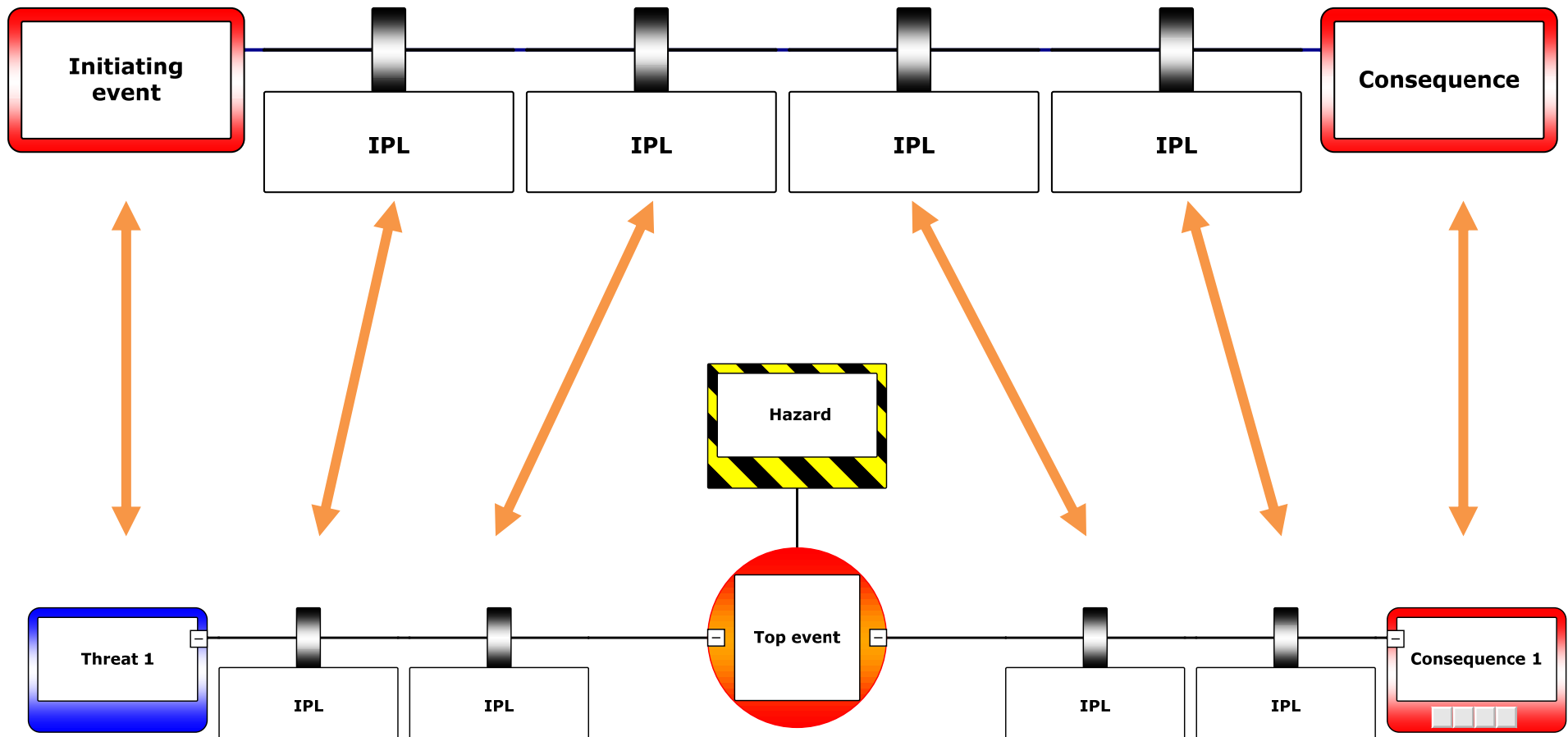
Thr. 2 – Cons. 3

Thr. 3 – Cons. 1

Thr. 3 – Cons. 2

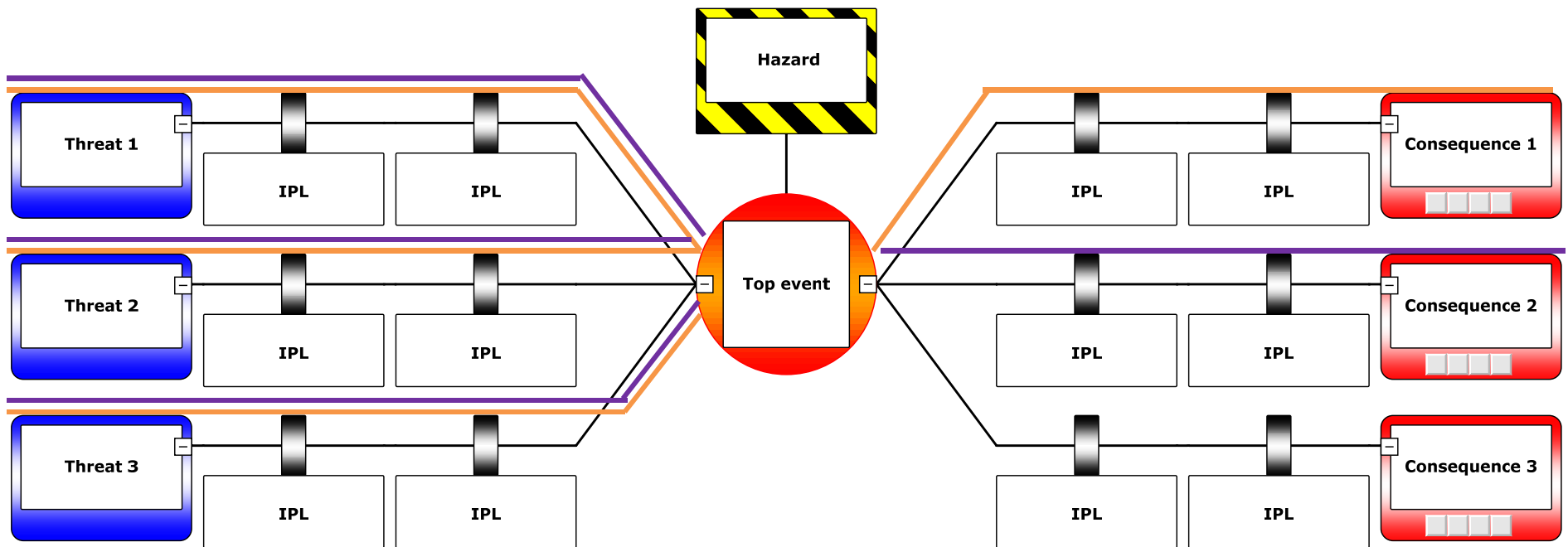
Thr. 3 – Cons. 3

Classical (non-bowtie based)



“Traditional” bowtie based

BowTie and LOPA: "BowTie adapted"



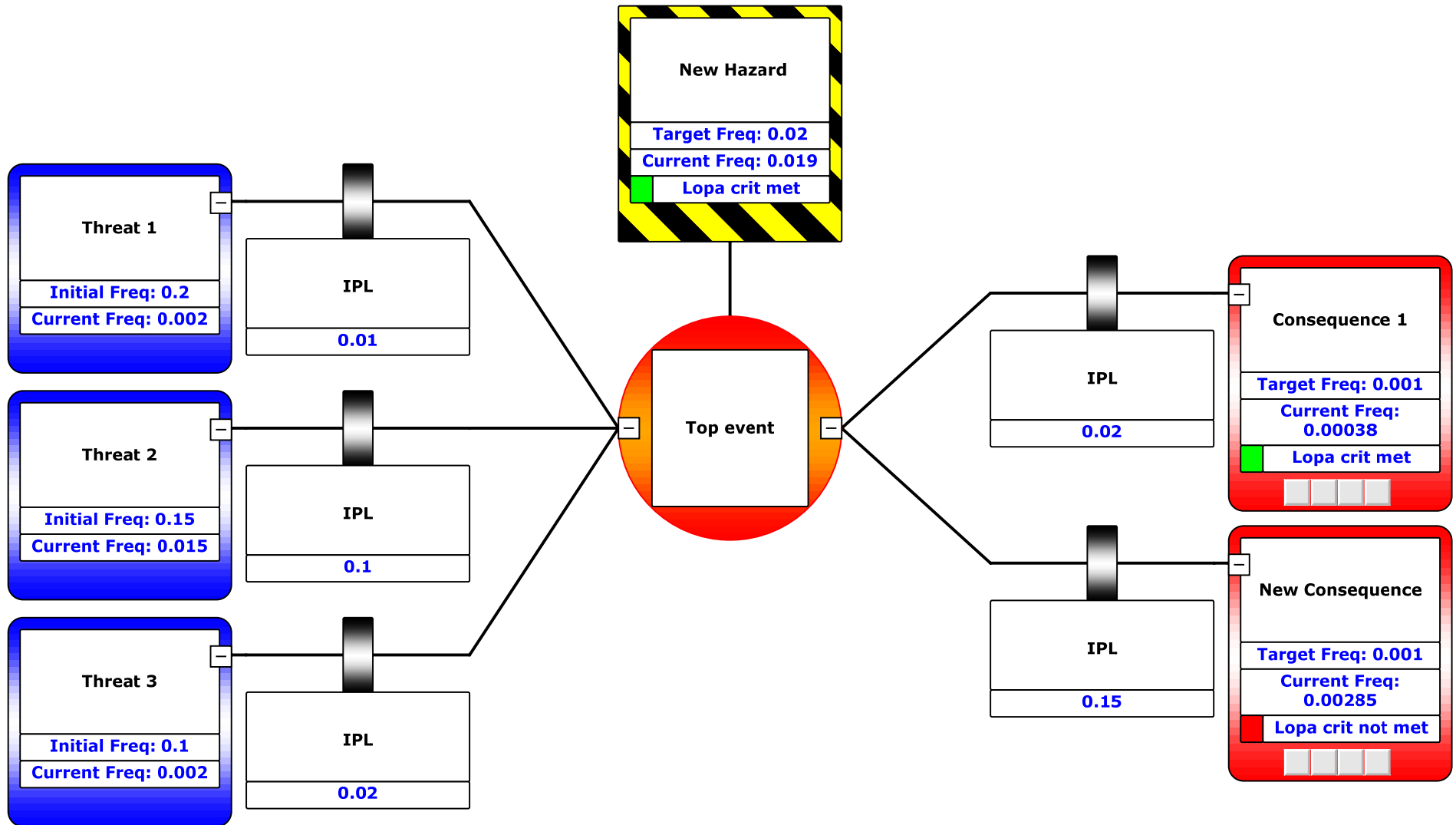
Calculate likelihood of Top-Event, then per consequence

 Thr. 1
 Thr. 2
 Thr. 3 } Cons. 1

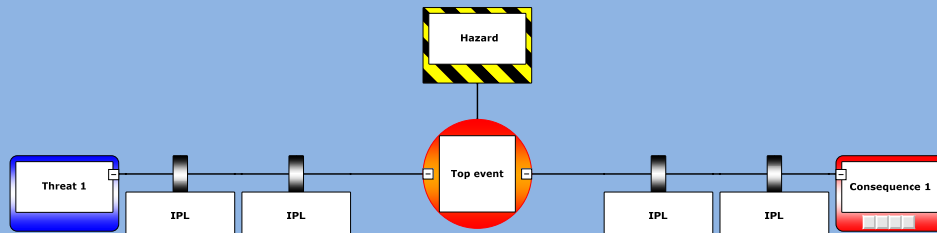
 Thr. 1
 Thr. 2
 Thr. 3 } Cons. 2

 Thr. 1
 Thr. 2
 Thr. 3 } Cons. 3

“BowTie adapted”



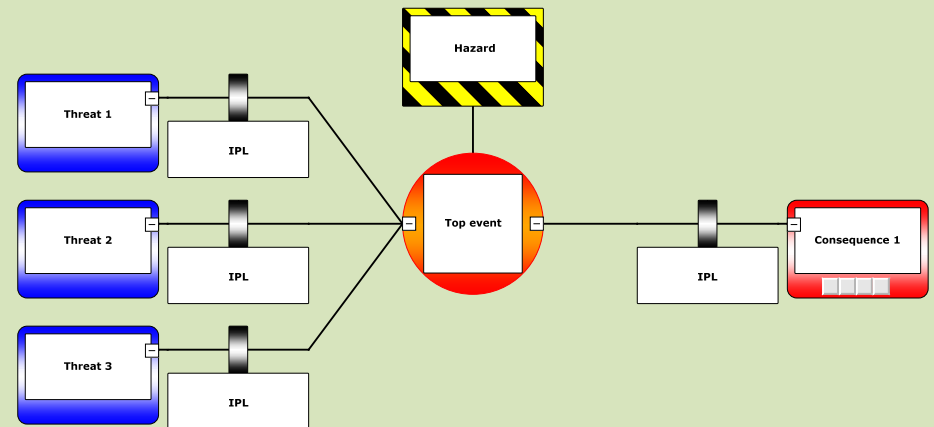
“Traditional”



Creates single line scenario's

- + Stays closer to classical LOPA
- + Can be used if not all Threats lead to all Consequences
- Neglects other threats
- Reports are more bulky

“BowTie adapted”



Uses H/TE as “half-way” calculation

The plugin shows this **by default**

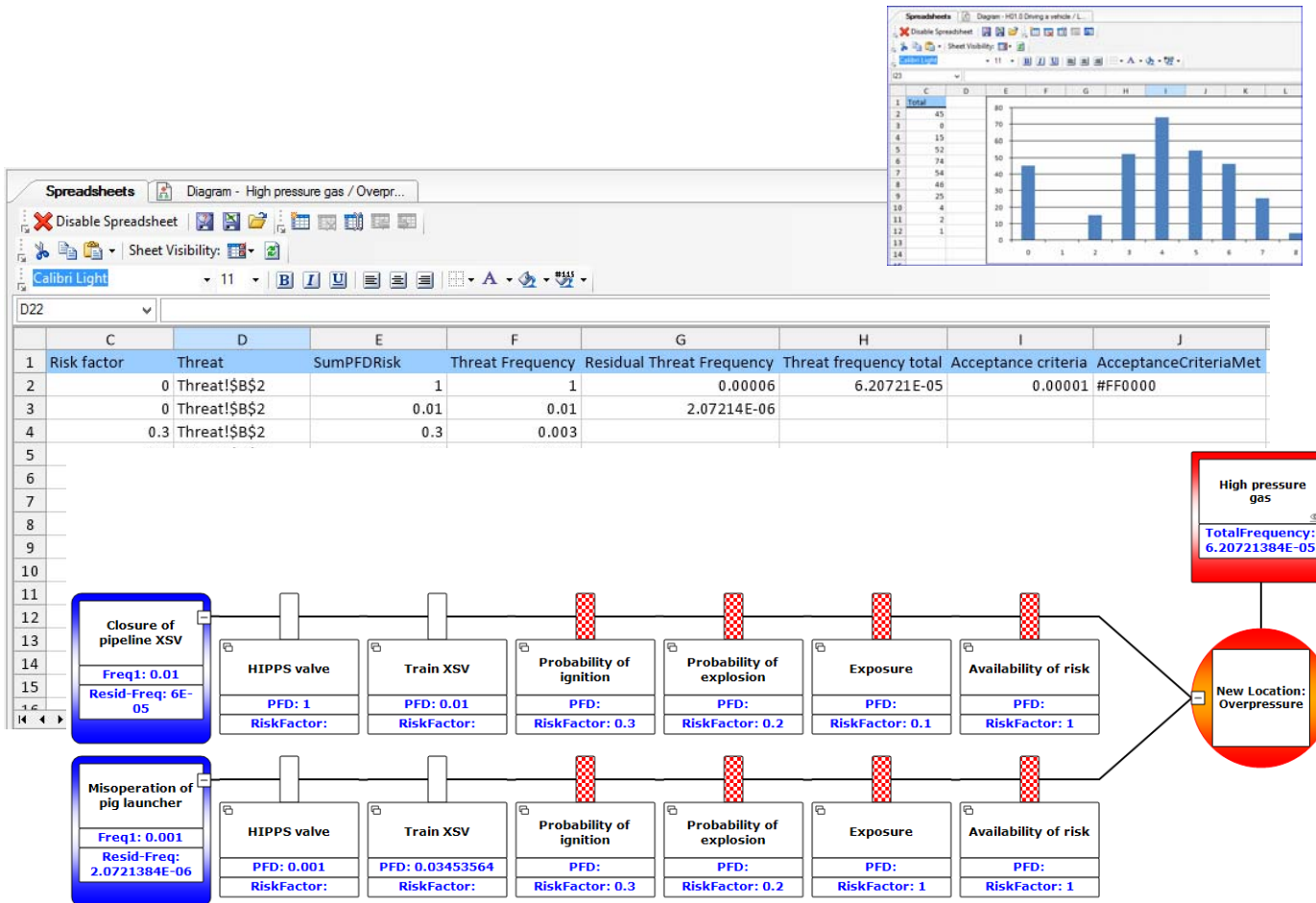
- + More logical model in the bowtie context.
- + Shows all results in one bowtie diagram.
- Moves away from classical LOPA

Quantify your bowtie diagram with

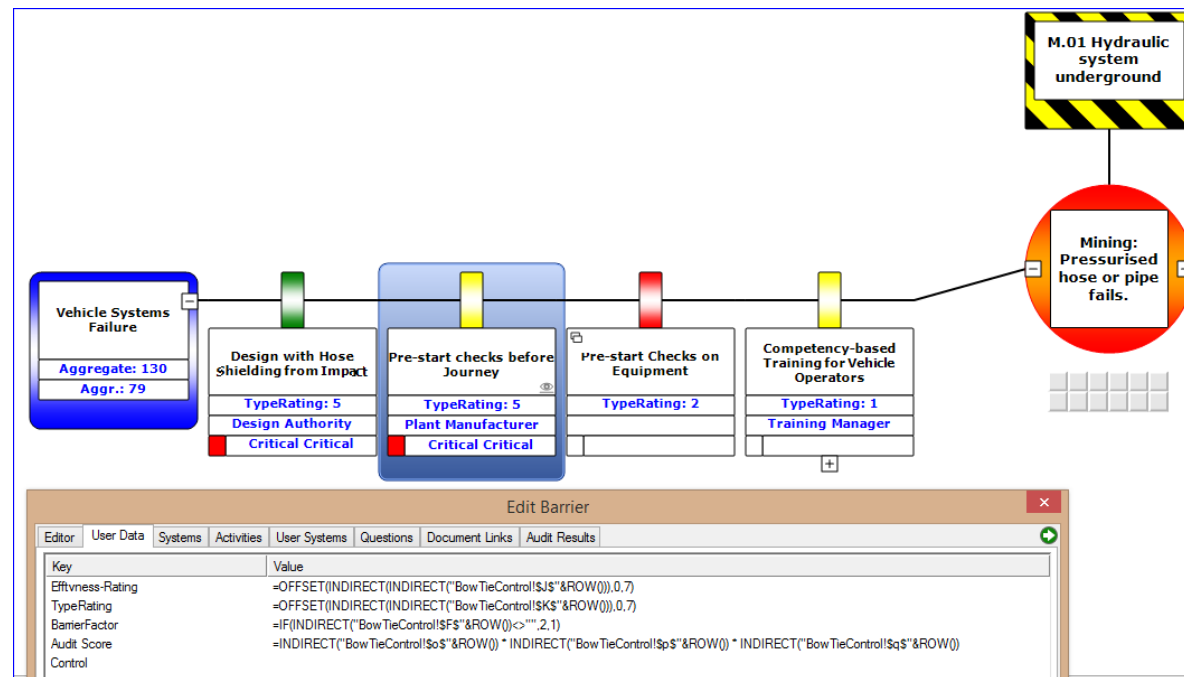
 **BowTieXL**

 **CGE**
Risk Management Solutions

BowTieXL



BowTieXL example



Bring your risk assessment to the cloud

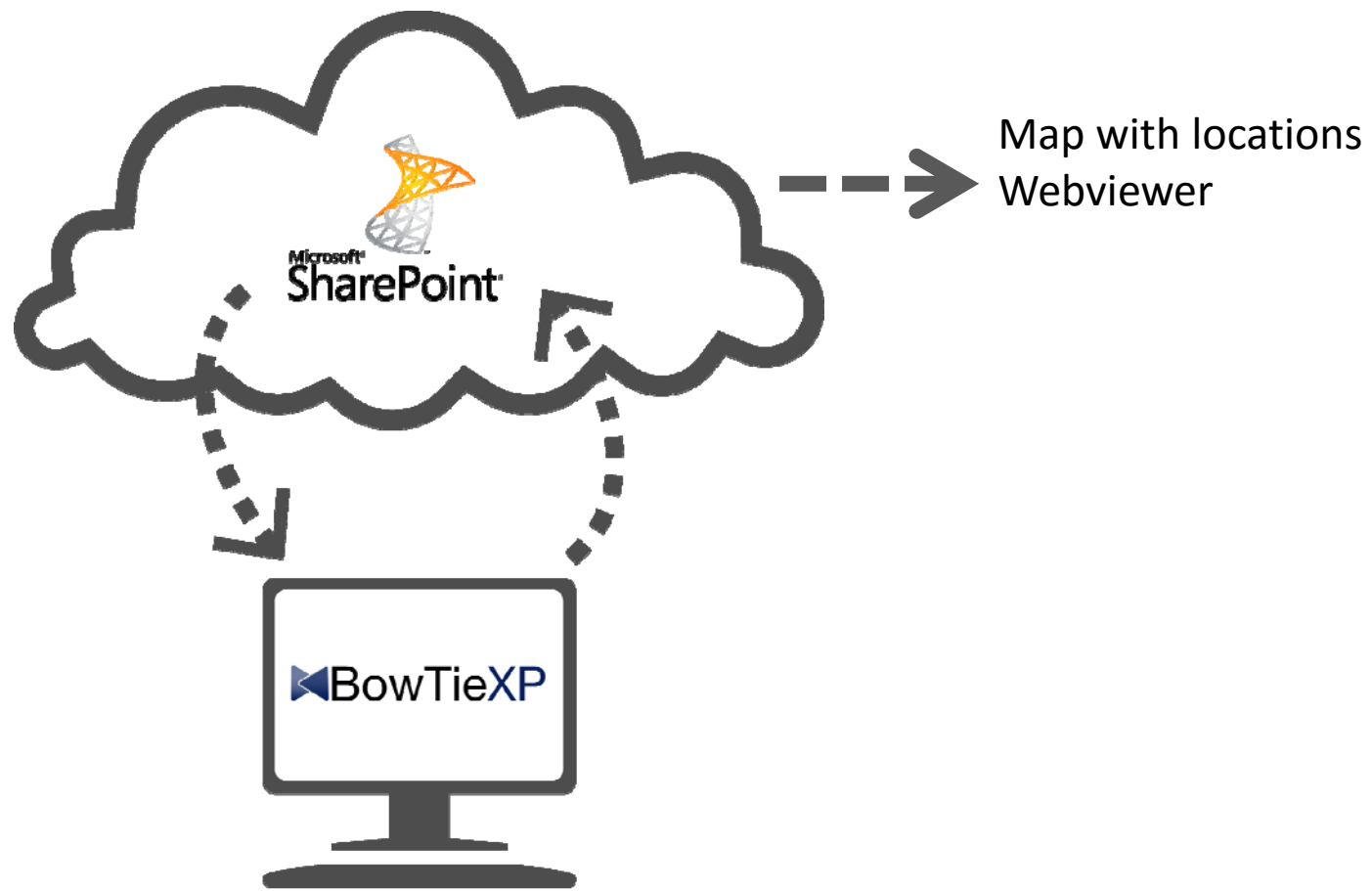


Sharing the Bowtie

Sharepoint

- Storing your BowTies
- Storing your document links

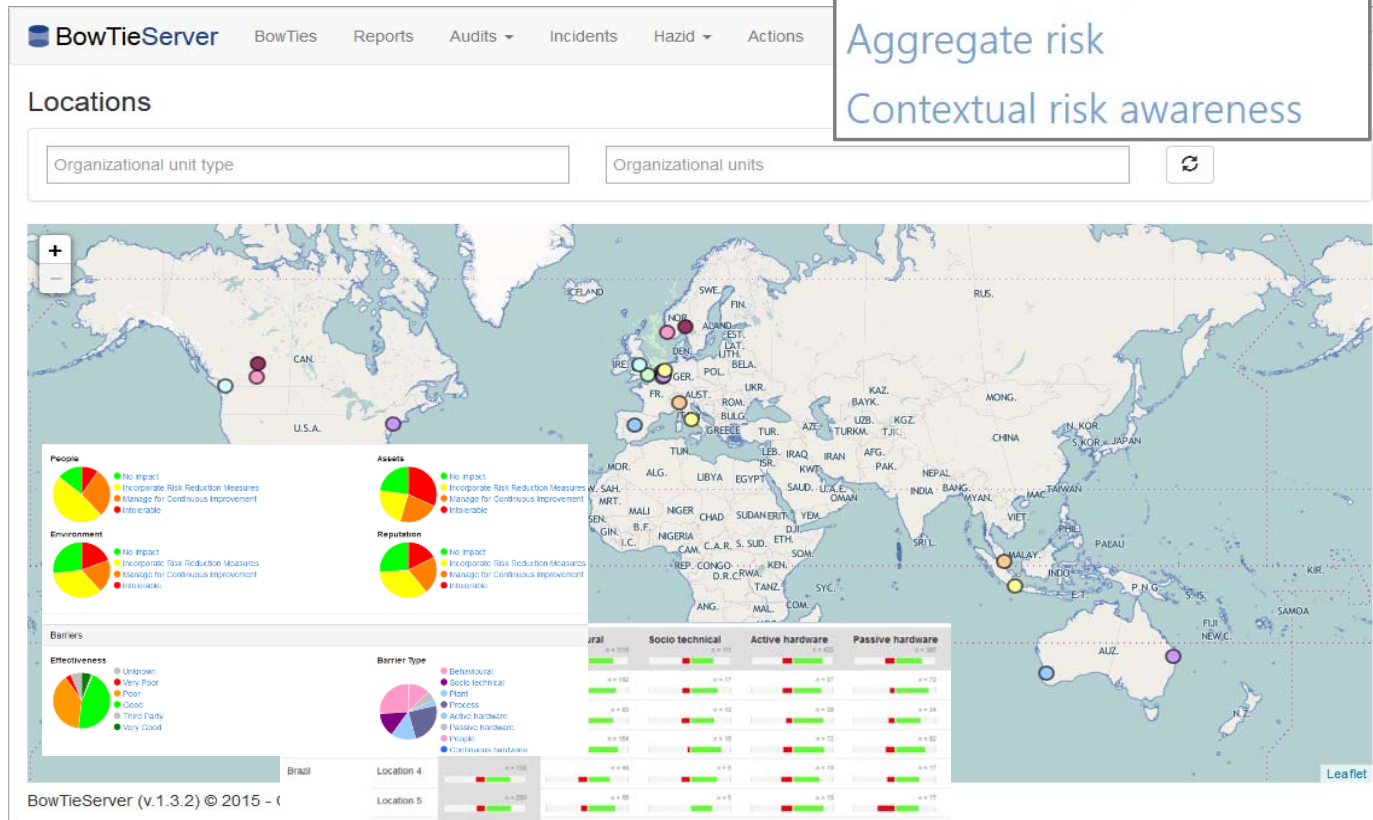




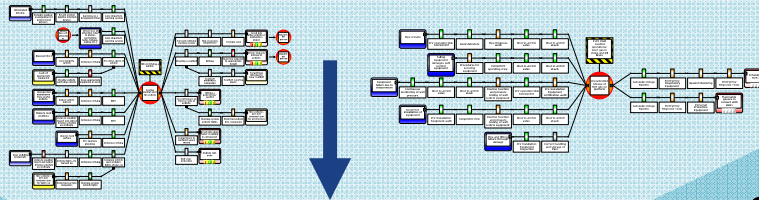
BowTieServer

Bringing BowTies to the Enterprise

Centralise risk information
Monitor barrier performance
Aggregate risk
Contextual risk awareness



1. Centralized BowTie Storage



2. Analyze data

- Organizational map
- BowTie registers
- Barrier Register
- Barrier History



3. Barrier Performance

- Audit data
- Incident data
- Maintenance data
- Permit data



- Hazid Module
- WorkBowTies



- Action Tracking
- Wiki documents

4. Platform for Applications