IOSH –Hazardous Industries Group

KPIs for Process Safety

LEARNING FROM 35 YEARS IN MAJOR HAZARD RISK CONTROL

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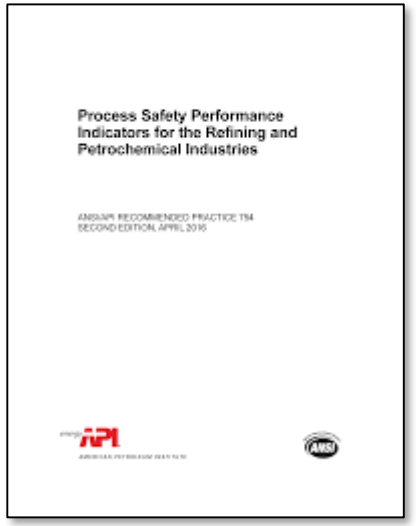
Why Measure?

- All systems [to control risks] deteriorate over time,
  - Some slowly, some quickly,
  - Some steadily, some erratically,
  - Some visibly and some out of sight.

- Measuring the performance of control & mitigation is an essential part of risk management,
- Spotting a system failure before an incident is better than fixing it after it has failed,
- So Leading Indicators have become the desirable focus of performance measurement.

What we have learnt since HSG 254 and API 574 were published?

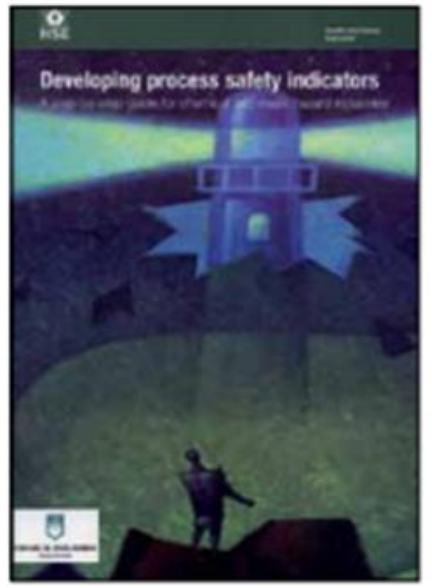


Major accidents continue to occur

Inquiries repeatedly point to failings in Process Safety Management and Leadership that could have been detected by an effective KPI programme

The case for having KPIs has never been clearer or stronger

But, many organisations are still having difficulty in implementing KPIs



So what's the problem?

Poor understanding of factors that need to be taken into account when establishing a KPI programme

Absence of effective leadership to drive forward a KPI programme

Over emphasis on the difference between leading & lagging indicators to the detriment of acting on information

So what's the problem?

Seeking a quick solution or simplistic measure of major hazard risk

A need for a better understanding of the difference between Sector Indicators and site-based indicators

An over focus on benchmarking

Demand for absolute proof that KPIs reduce the risk of a major accident

Factors to take into account

Engagement with the workforce

The need for everyone to understand and agree on the ‘risks’,

How negative results will be treated

The accuracy with which the KPI reflects the condition and status of a control measure

How easily and reliably data can be captured

Essential Characteristics of KPIs

Reflect the consensus of the risk profile of the organisation/ activity

Tailored to the specific risks

Focus on vulnerability and provide opportunity for early intervention

Based on data already available

What each KPI measures and why the issue is important clearly defined

The Importance of Leadership

Persuade me vs I insist

Most senior executives need to be strongly persuaded why a KPI programme is needed rather than expecting or demanding that such a programme is implemented

Sector vs Site-specific KPIs

No ‘one size fits all’ solution

KPIs need to be tailored to the risks present at each facility or installation

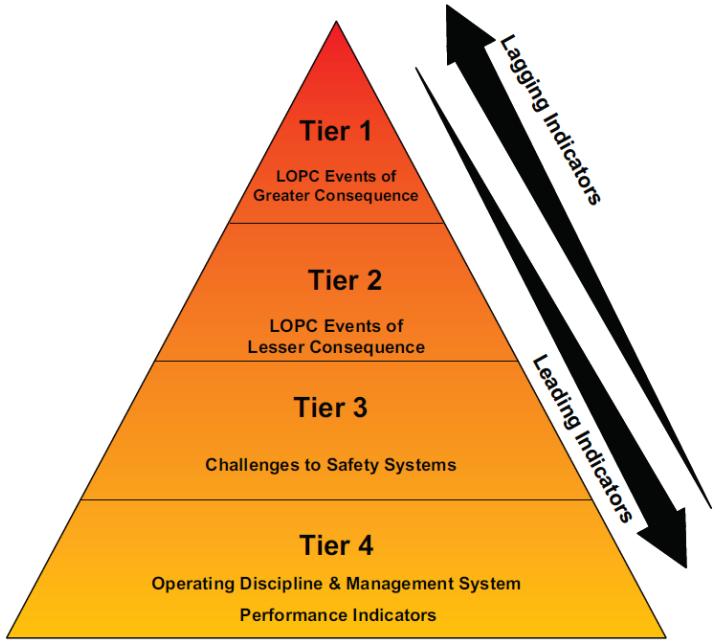
Generic indicators will be less focused

Sector-based indicators can realistically only succeed where they reflect the main risks present in all operations

Benchmarking is useful but not the main aim of a KPI programme

A Moment on Leading & Lagging Indicators

- To keep you sane:
  - Information is more important than the ‘label’,
  - You will never get universal agreement on what is a ‘leading’ or ‘lagging’ indicator,
  - Even API hedged it,
  - So, don’t waste lots of time debating these categories.



Leading and Lagging Indicators

Input

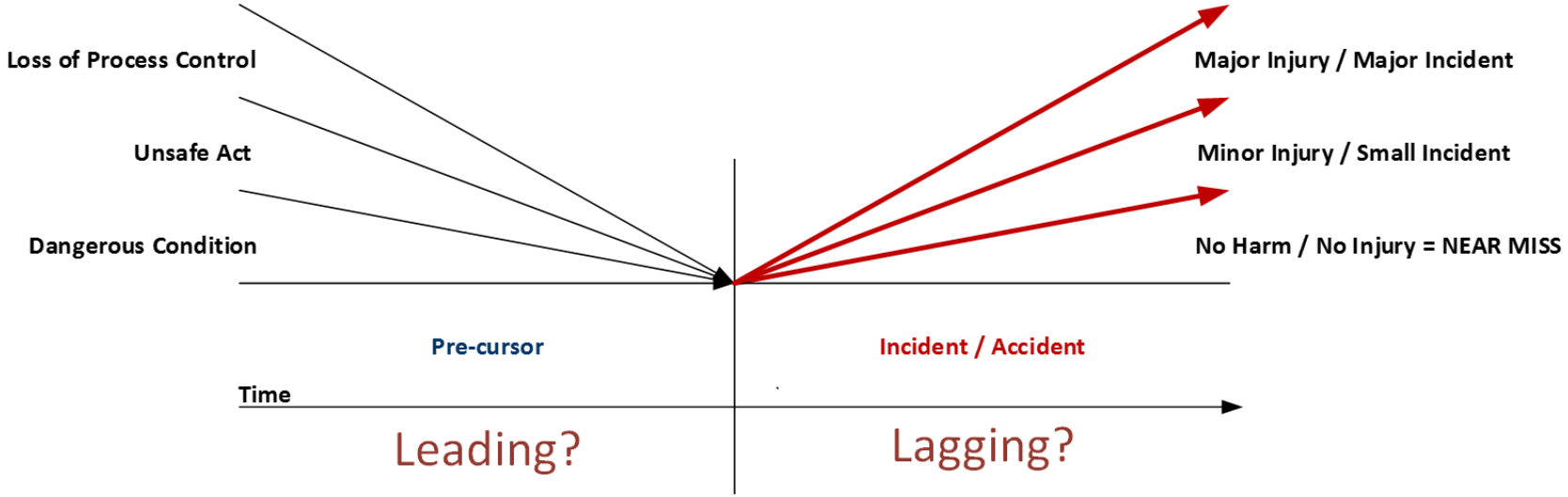
Leading indicators monitor and measure whether the important activities are in place to deliver the ‘outcome’ of the control of risk.

Outcome

Lagging indicators monitor and measure the ‘outcome’ of the control of risk. Success or Failure

A Moment on Leading & Lagging Indicators

- But is Leading vs Lagging a temporal consideration?
- In other words – is measuring anything before an accident or an incident a leading indicator and measuring accidents and incidents a lagging indicator?
- In which case a, near-miss will be a lagging indicator



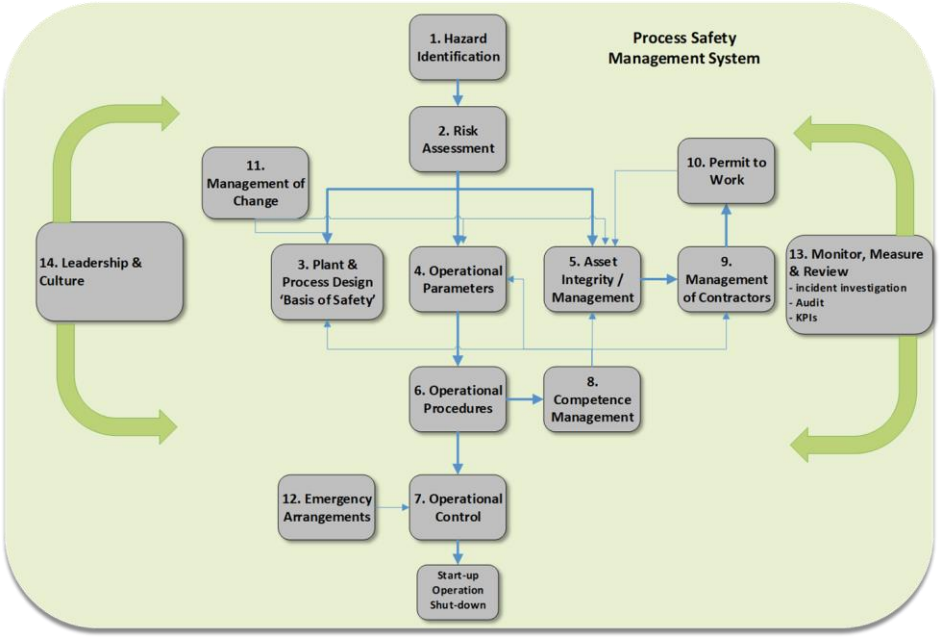
Not all KPIs are Equal

- Set the desired outcomes around the most significant challenges to the process safety integrity of the plant or process.
- From HSE / HSL research these are:
  - Corrosion,
  - High / low temperature,
  - High / low pressure,
  - High / low level,
  - Mechanical failure – e.g. material, joint or seal failure, wear and erosion,
  - Impact,
  - Human error – e.g. opening into containment.

Not all KPIs are Equal

Set the desired outcomes around the key components of a process safety management system.

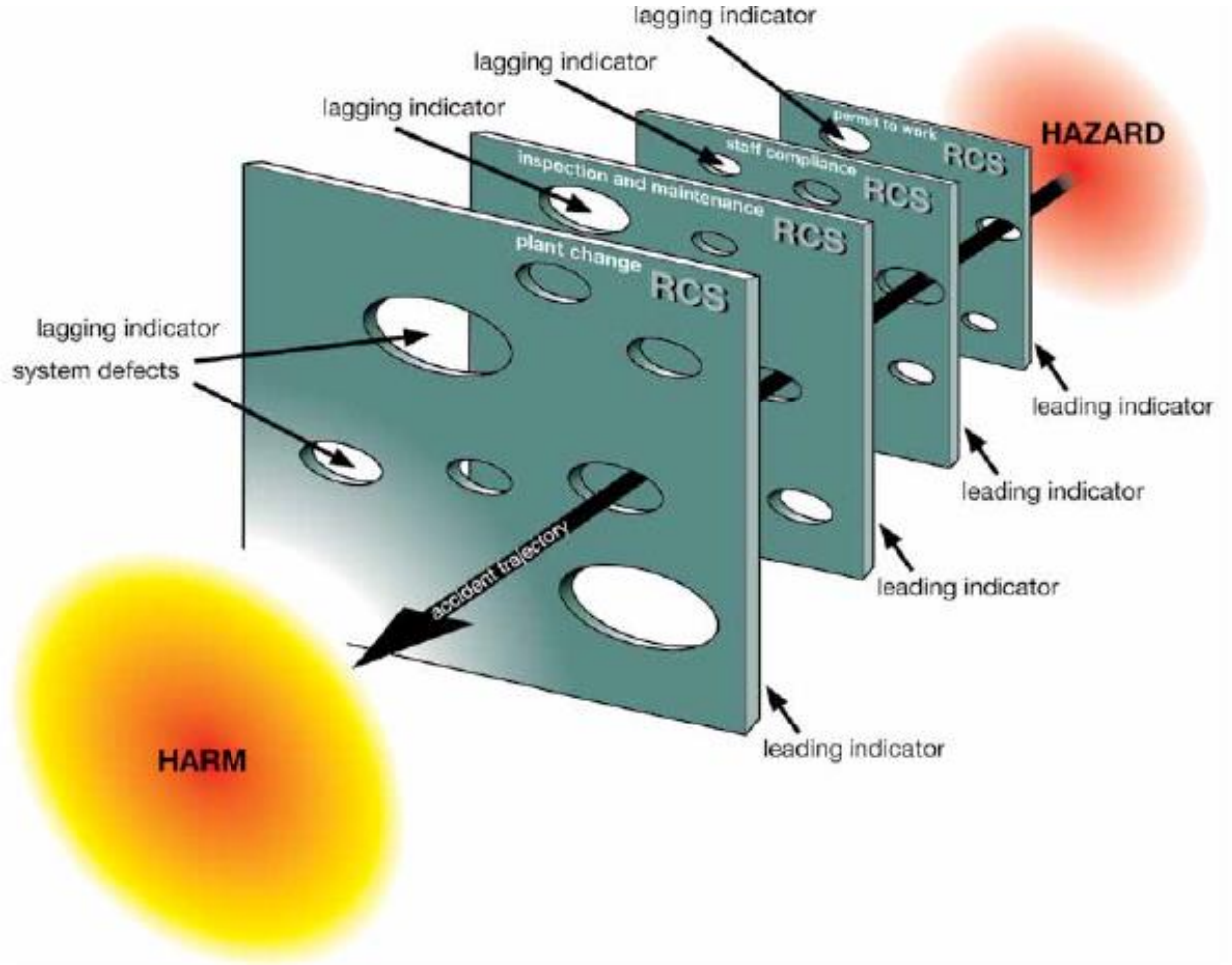
- Hazard Identification
- Risk Assessment
- Plant Design
- Operational Parameters
- Operational Procedures
- Operational Control
- Competence

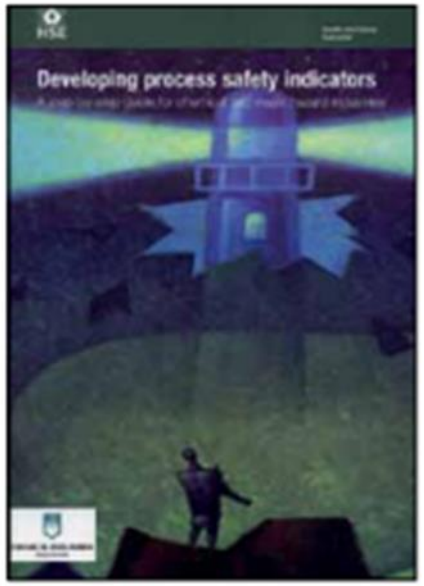


- Management of contractors
- Permit to Work
- Management of change
- Emergency Arrangements
- Monitoring, Measuring & Review of performance
- Leadership & Culture

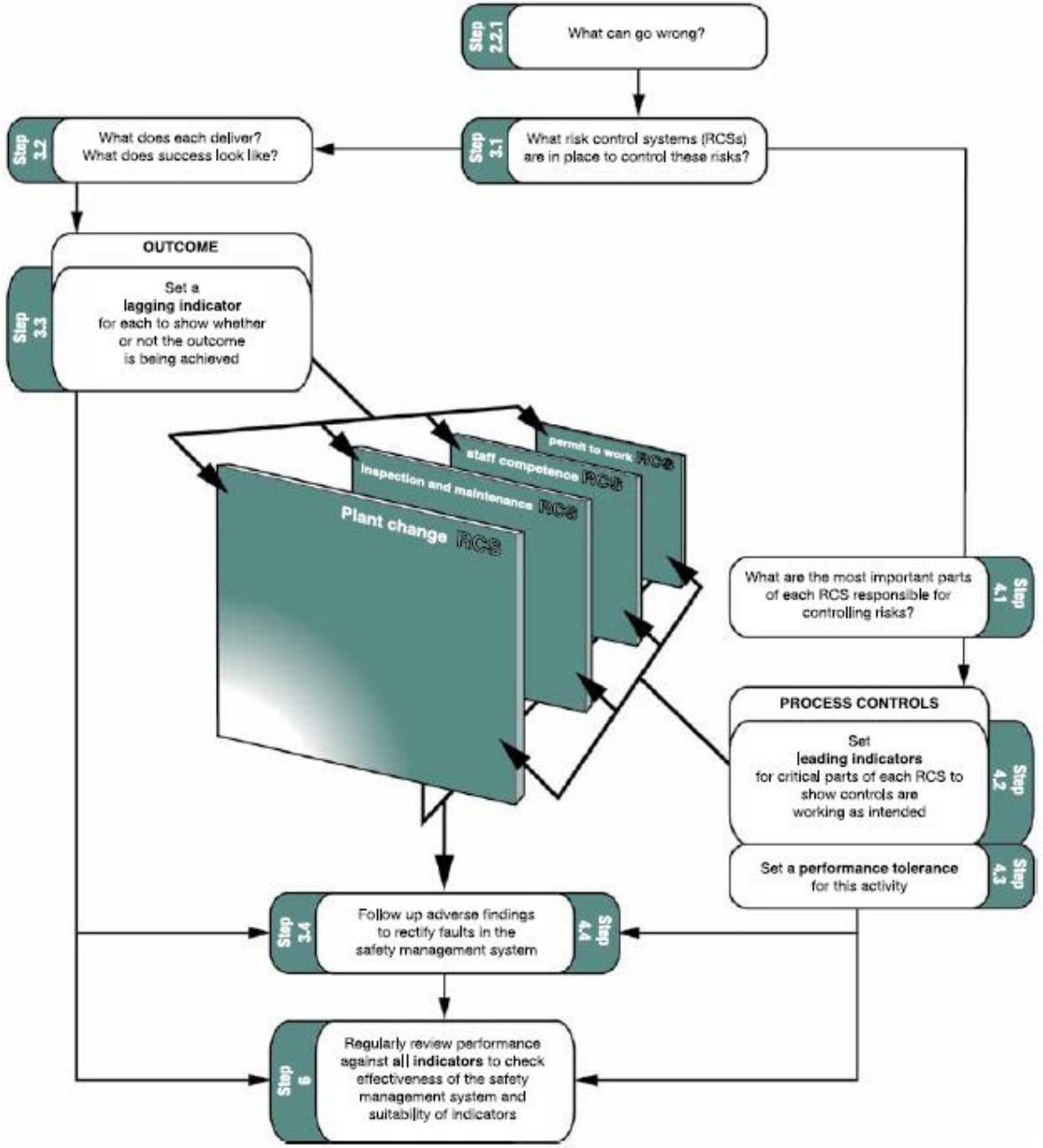
Measure the Right Things

- Measure the things that show your control systems are working,
- That is, delivering the desired outcomes,
- Avoid measuring system content unless the activity is the most important task / process that delivers the desired outcome.


lagging indicator
lagging indicator
lagging indicator
HAZARD
permit to work
staff compliance
inspection and maintenance
plant change
RCS
RCS
RCS
RCS
lagging indicator
system defects
leading indicator
leading indicator
leading indicator
leading indicator
accident trajectory
HARM

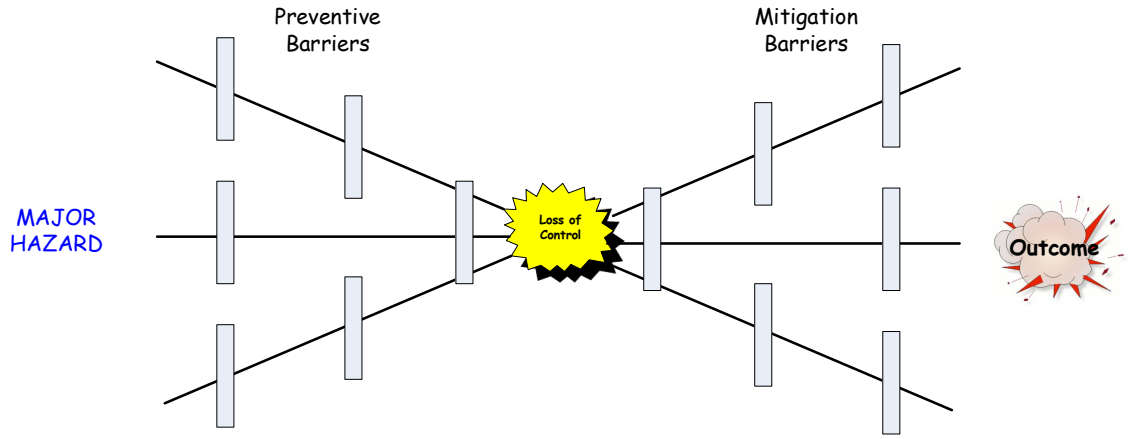


HSG 254 – a methodology not a set of KPIs



The Problem with ‘Near-Miss’

- Any loss of control is an unintended failure to control risk,
- Of ‘no consequence’ is of no comfort,
- Difference between harm and no harm is often just chance.

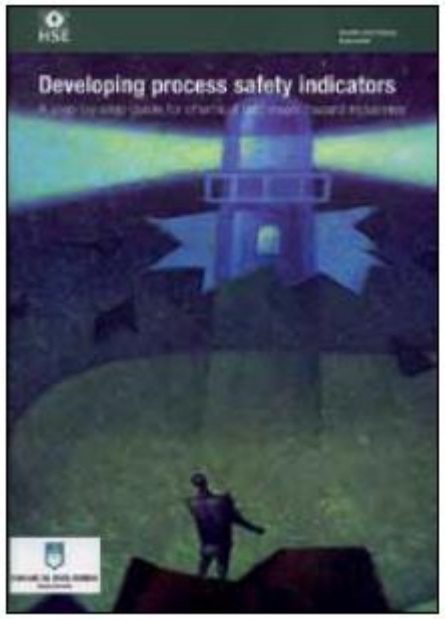


- But any loss of control is an adverse, unwanted outcome which will always provide a valuable insight.

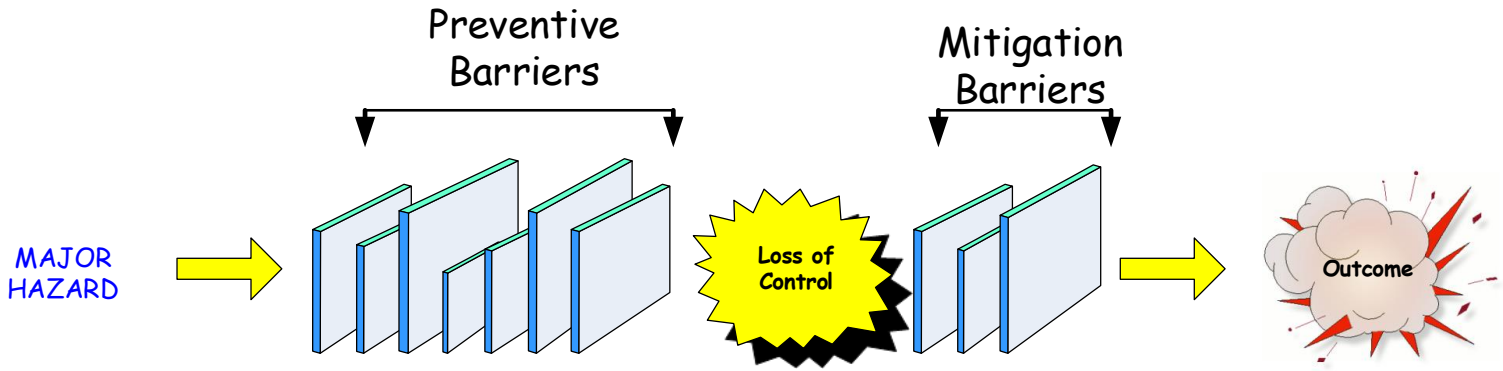
Process Safety Outcomes

If you don't clearly identify the 'desired safety outcome' in terms of 'success', it will be impossible to identify indicators that show the desired outcome is being achieved.

- Every Risk Control System or Barrier will have a desired outcome



HSG 254



Focus on what really matters

- How could it go catastrophically wrong?
- Where / when will most likely go wrong?
- What controls or systems are there to prevent a major incident?
- Which of these controls are most vulnerable to failure?
- What information do you have to show those systems continue to operate to the desired performance standard?

The Outcome Headache

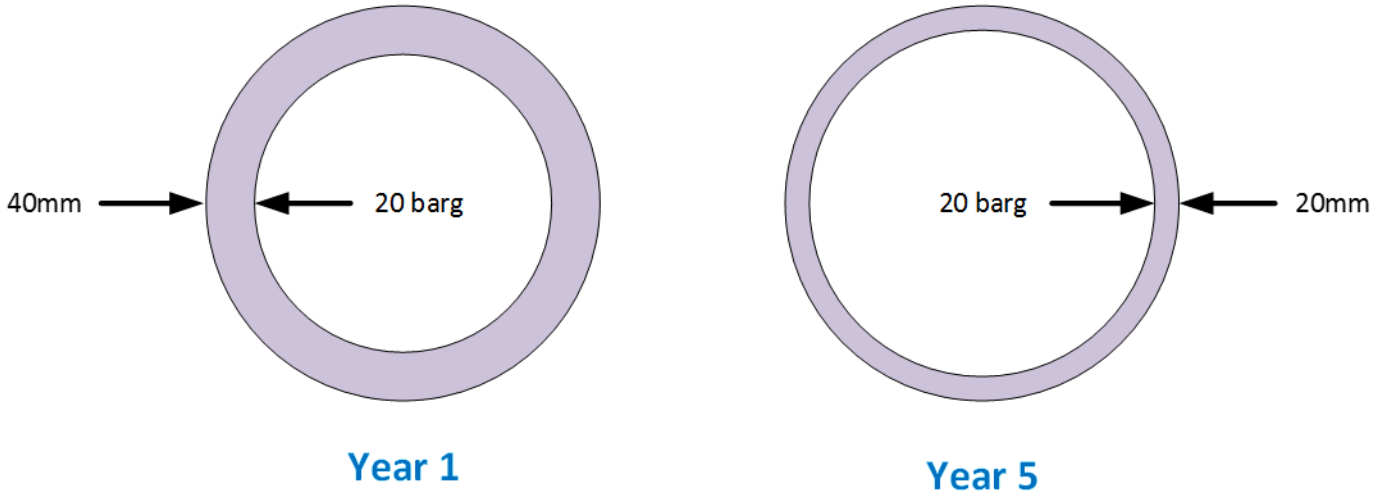
- So what are the intended (successful) outcomes of the common control systems in place?

- Try completing this sentence:
  'We have a Management of Change System in order to……'

- Then share your answer with your neighbour or colleague.
- Did you both agree?

Less Easy Outcomes

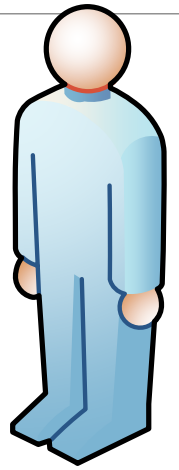
- Management of Corrosion?



- Outcome = sufficient wall thickness left to contain the maximum internal pressure

Less Easy Outcomes

- Competence?
- Competence is an outcome not a process.



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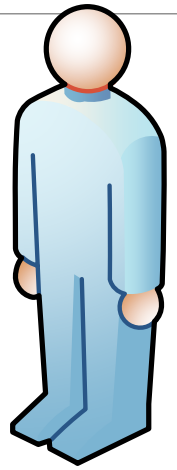


- Outcome = a (safety critical) task is undertaken the way it was intended.

System Outcomes

Control system or barrier	Successful outcome
Level control	Level is maintained with designed normal operational limits – (not to the high level alarm level).
Pressure control	Pressure is maintained within designed normal operational limits– (not to the high level alarm level).
Temperature control	Temperature is maintained within designed normal operational limits– (not to the high level alarm level).
Corrosion management	Sufficient wall thickness remains to contain the maximum pressure in the pipe/ vessel.
Mechanical integrity	The containment degrades at the predicted rate. The equipment continues to operate between inspection / maintenance intervals.
Human performance	Tasks are performed to the required standard.
PTW system	Permission is sought and granted ahead of high risk maintenance activities being started. The safeguards / isolations in the permit are followed in full.
Management of change	Permission is sought and granted ahead of any change to the process / plant or procedure. The outcomes in changed performance / function proposed by the change are achieved in practice.
Inspection and maintenance	The correct functioning of the item of plant / equipment is confirmed or any fault properly diagnosed. The correct functioning of the item of plant / equipment is restored to the desired standard.

Lagging Indicators – key questions

- Is there agreement on the desired ‘outcome’ or what the wrong outcome is?
- Can the outcome be detected and recorded?
- Is there any tolerance on the outcome?
- What metric should be used?
- What is the source of the data / accuracy / frequency /reliability?

Leading Indicators – key questions

- Which are the most important activities / inputs essential to deliver the outcome?
- What must go right every time to get the outcome?
- Can the input be measured consistently?
- What metric should be used?
- What is the source of the data / accuracy / frequency /reliability?

Setting KPIs for challenges to process integrity

Sketch out the process / activities

Identify and map onto the process diagram the main challenges to integrity

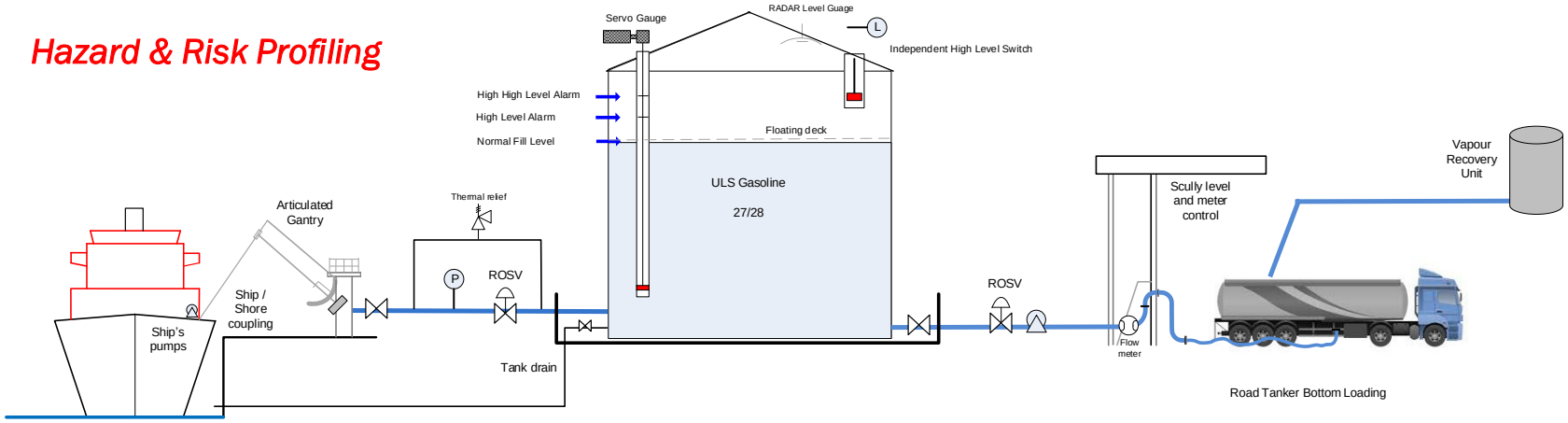
Identify what systems and barriers exist to prevent those challenges materialising

Select the most important in terms of criticality and vulnerability

Choose the best fit lagging indicators – to detect adverse outcomes at the earliest opportunity

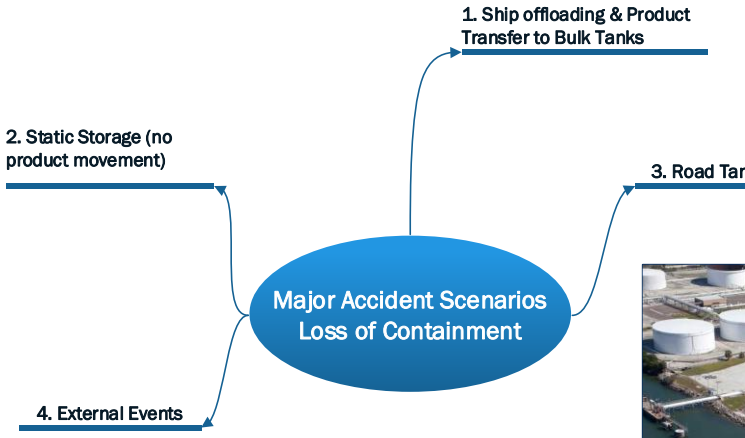
Choose leading indicators to show the most vital activities are being followed to deliver the desired outcome

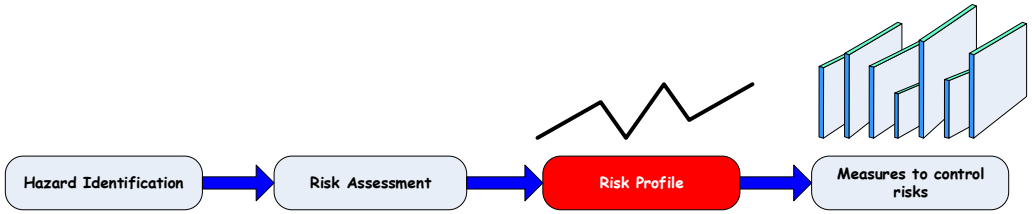
Hazard & Risk Profiling



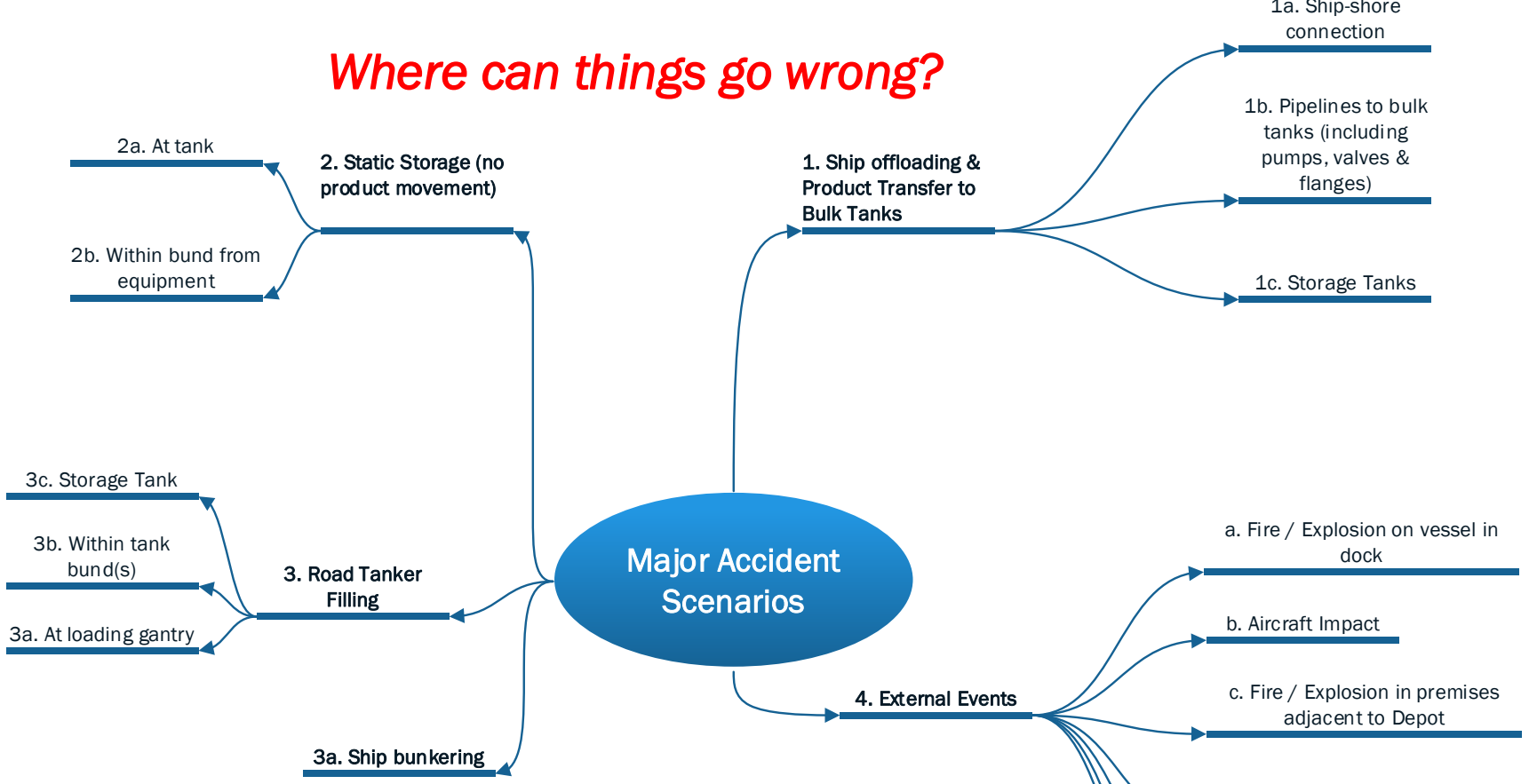
Sketch out the process / activities

Terminal
Gasoline Storage and Dispatch
Process Description

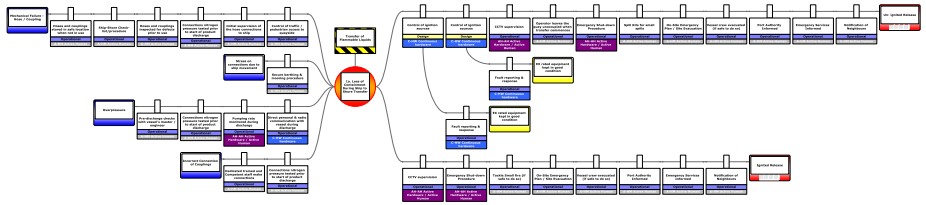




Where can things go wrong?

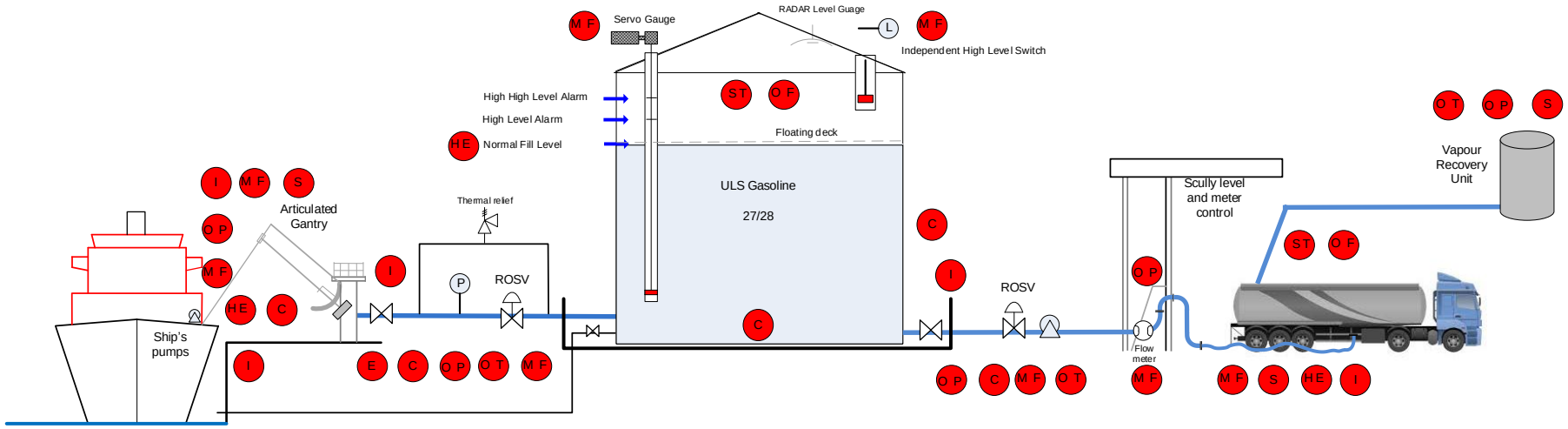


Set the scope of the analysis for each scenario



Fuel Terminal Major Hazard Scenarios

PSM Framework
1. Hazard Identification



Identify and map onto the process diagram the main challenges to integrity

Terminal Gasoline Storage and Dispatch
Challenges to Integrity

Challenges to Integrity

- C Corrosion
- E Erosion
- MF Mechanical Failure
- OF Overfilling
- OP Over Pressure
- OT Over Temperature (thermal expansion)
- HE Human Error
- I Impact
- S Stress
- ST Static

How and where could things fail?

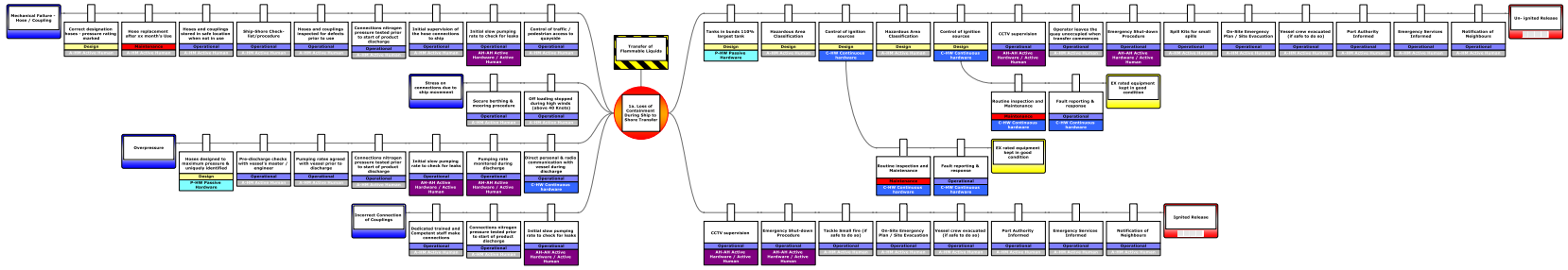
PSM Framework
1. Hazard Identification

What controls and mitigation measures are in place to prevent a loss of control?

MAH 1.a Loss of Containment During Ship Offloading

What measures are in place to prevent an initiating event leading to a loss of control?

What measures are in place to prevent or limit the consequences of a loss of control?



Are sufficient numbers of control measures in place?

What are the characteristics of the control measures – are they robust enough?

Do they reduce risk to as low as is reasonably practicable, ALARP?

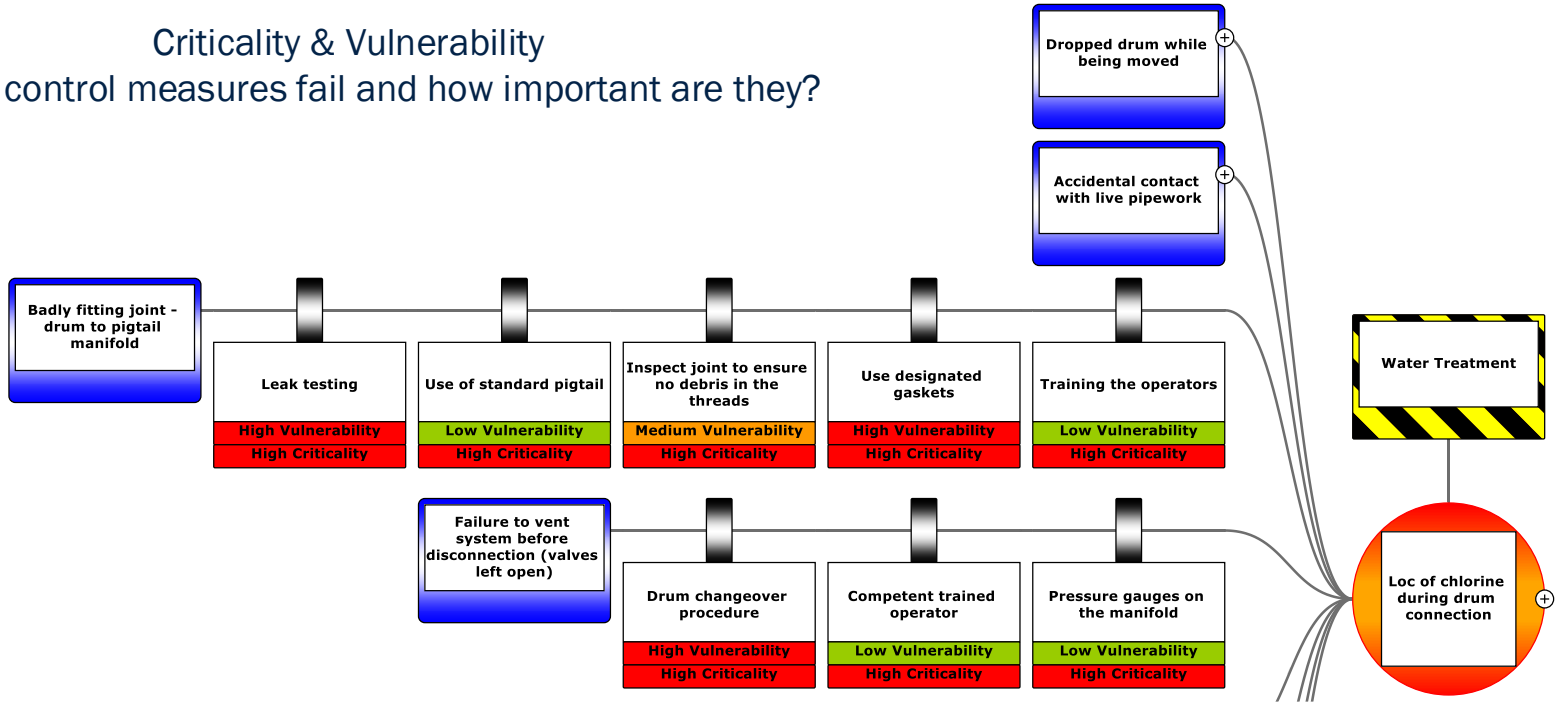
How was selection of control & mitigation measures made? What risk assessment methods were used?

Fuel Terminal Major Hazard Scenarios

Barrier Types
P-HW – Passive Hardware
A- HW – Active Hardware
AH-AH Active Hardware / Active Human
A-AM – Active Human
C-HW – Continuous Hardware

PSM Framework
2. Risk Assessment

Criticality & Vulnerability
How do control measures fail and how important are they?



Vulnerability guide questions:

Does the control measure / barrier fail in a predictable and well understood way and time in the plant lifecycle?

Does the control measure / barrier provide any 'early warning, of failure e.g. leak before fail, excess vibration to flag up a potential component failure?

Is there is opportunity to recover the loss of containment, e.g. limit the extent of release, rapidly shut down the system or to capture or contain the release through bunding or other secondary containment measures?

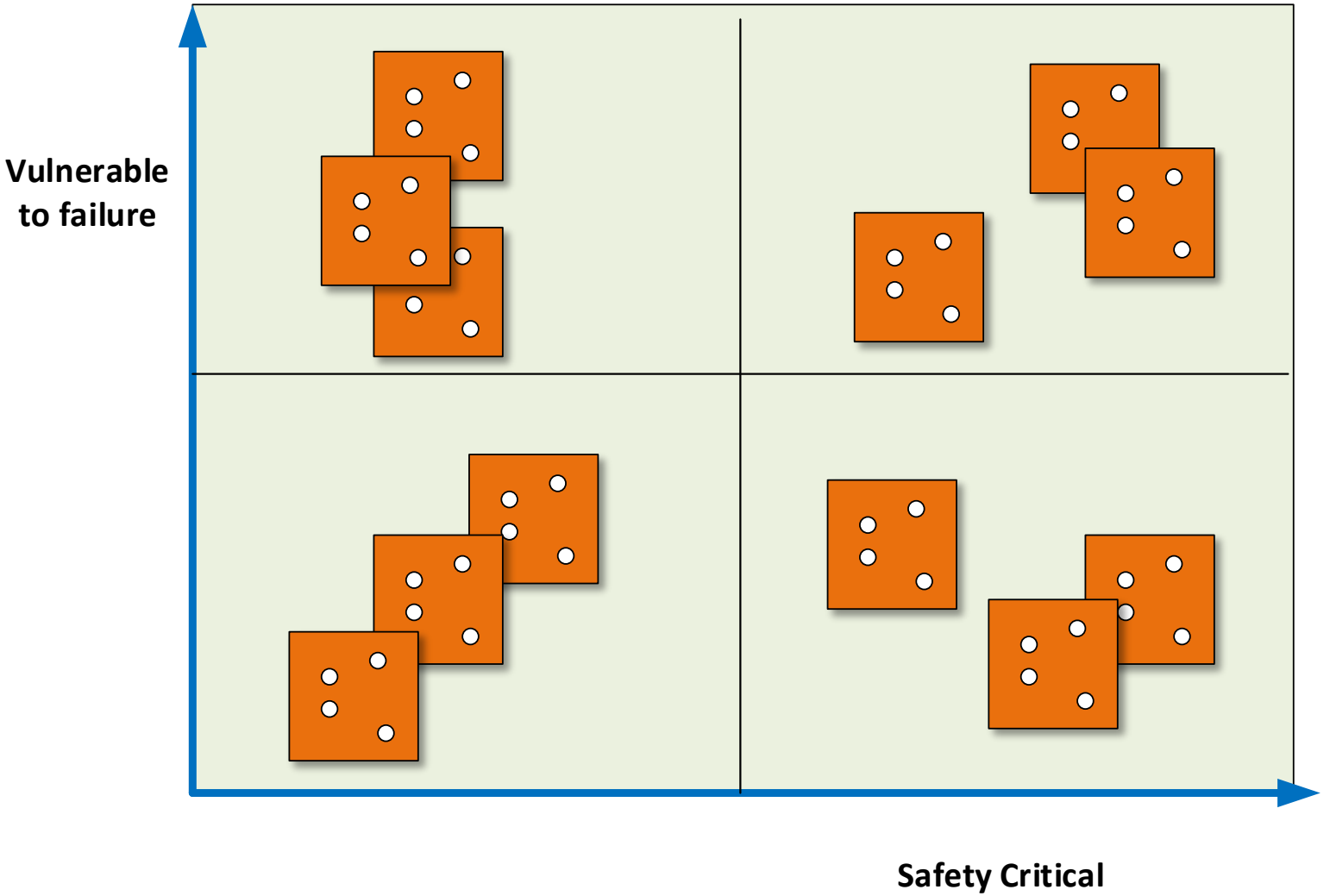
Does the correct functioning of the control measure rely partly or wholly on human intervention?

Is the barrier 'last in line' in the hierarchy of control measures e.g. if it fails there will be a loss of containment?

Safety Critical guide questions:

Does the barrier lie on the critical path to a major accident e.g. is this a major hazard initiator should it fail?
Does the control measure / barrier directly relate to controlling process conditions e.g. temperature, pressure, flow, level which could directly lead to a loss of containment?
Does the control measure / barrier guard against another important loss of containment failure mechanism, e.g. corrosion, stress, impact?
How essential is the control or mitigation measure in preventing a loss of containment e.g.

- **Essential?**
- **Important?**
- **Moderately relevant?**
- **Marginal?**
- **Supplementary / adjunct to a more important control measure?**

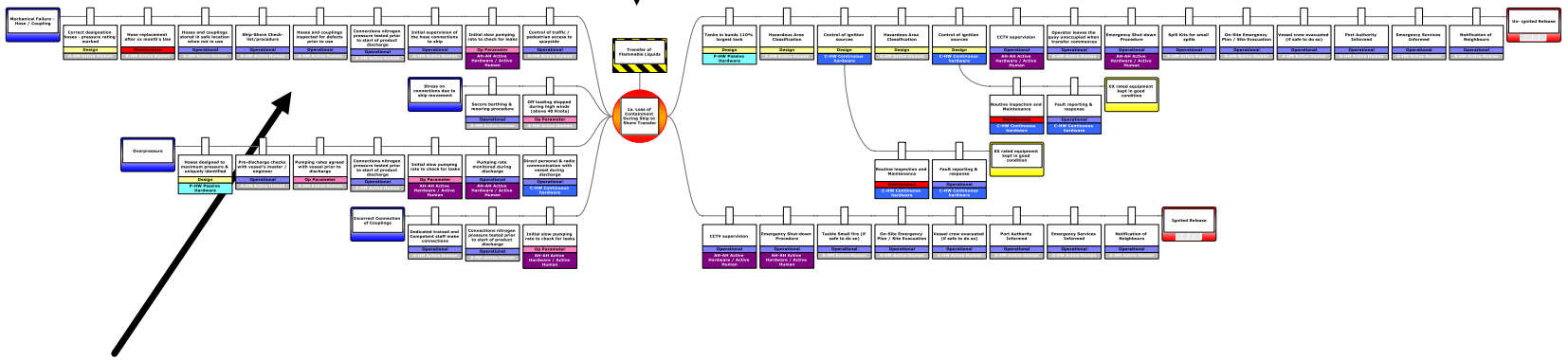

Vulnerable to failure
Safety Critical

What KPIs should be measured?

Whenever a threat arises, even if it results in no harm?

Whenever a loss of control occurs, even if it results in no harm?

Whenever a harmful outcome occurs?



Whether operational procedures are always followed?

Whether all maintenance actions are up to date?

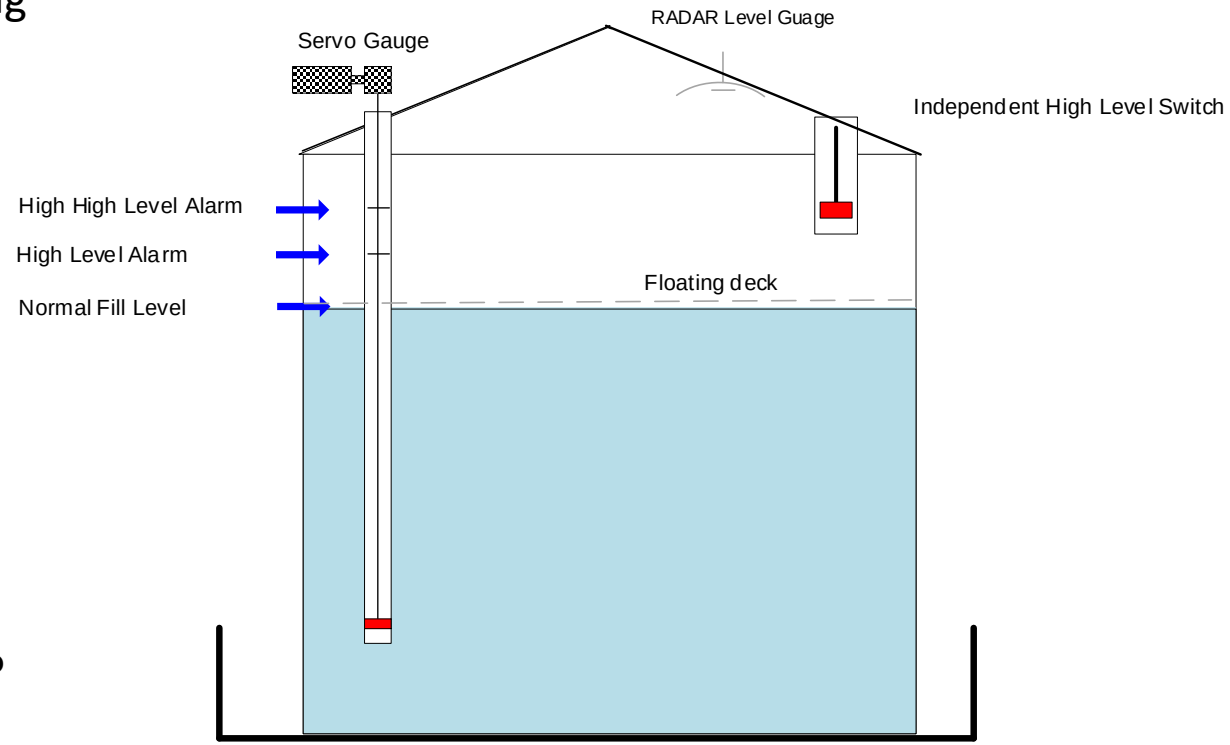
Fuel Terminals
Major Incident Scenarios

Barrier Types
P-HW – Passive Hardware
A- HW – Active Hardware
AH-AH Active Hardware / Active Human
A-AM – Active Human
C-HW – Continuous Hardware

KPIs

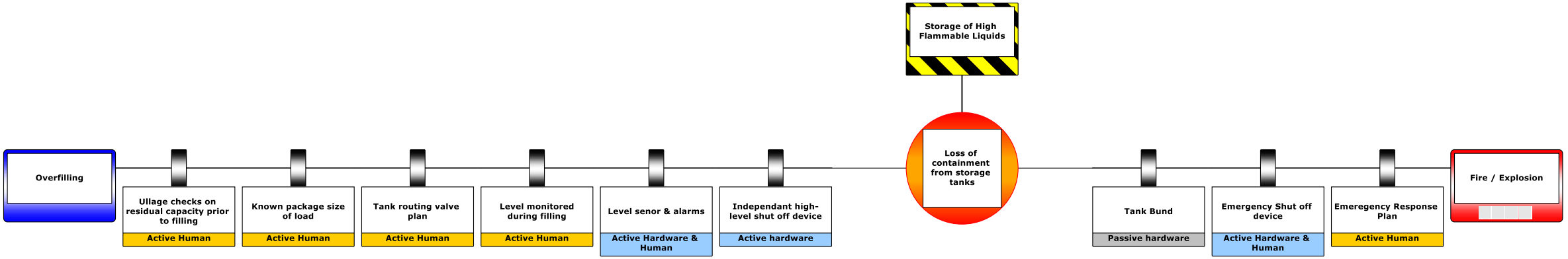
PSM Framework
13. Monitor, measure and review performance

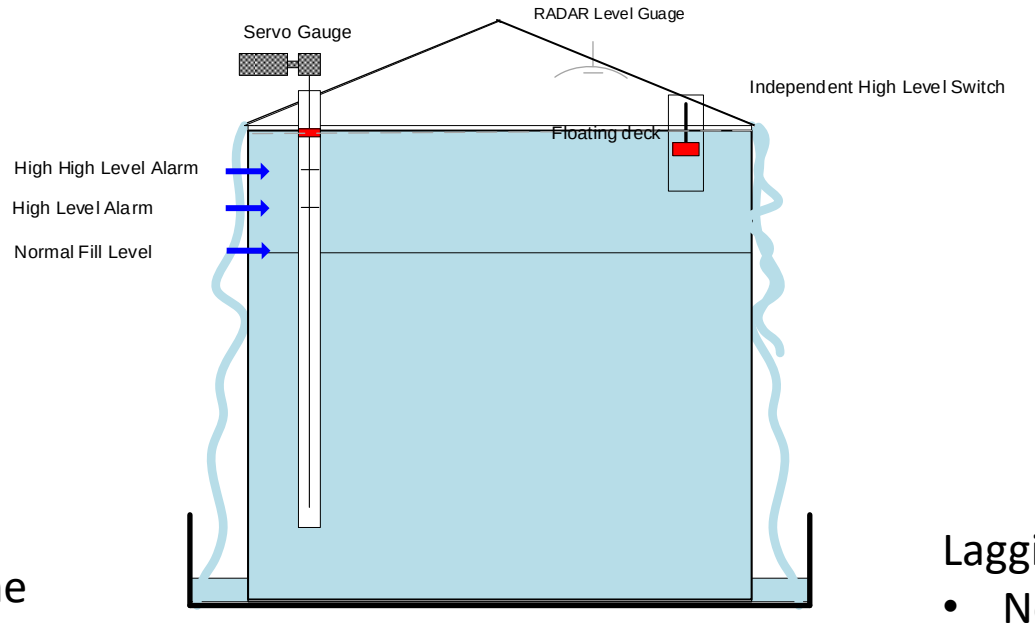
KPIs for tank overfilling



Leading indicator?

Lagging indicator?



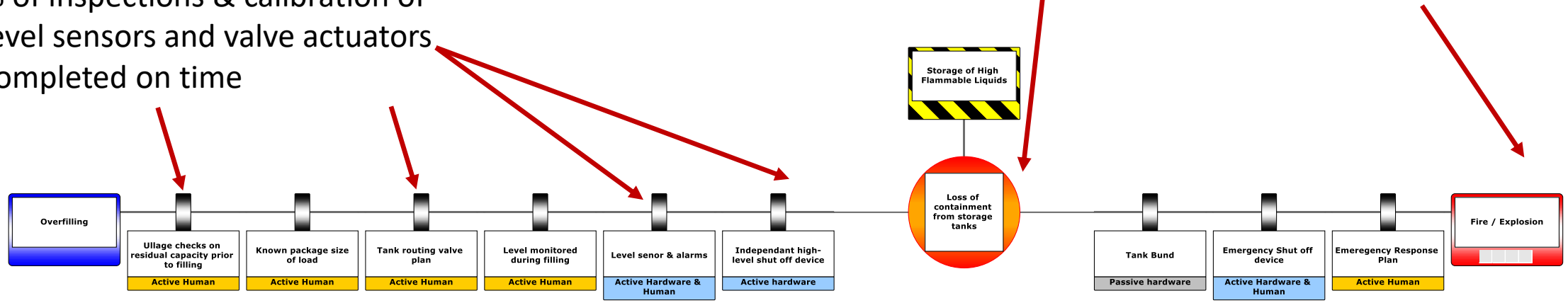


Leading indicators:

- % times ullage calculation done correctly
- %. times the tank routing valves are set correctly
- % of inspections & calibration of level sensors and valve actuators completed on time

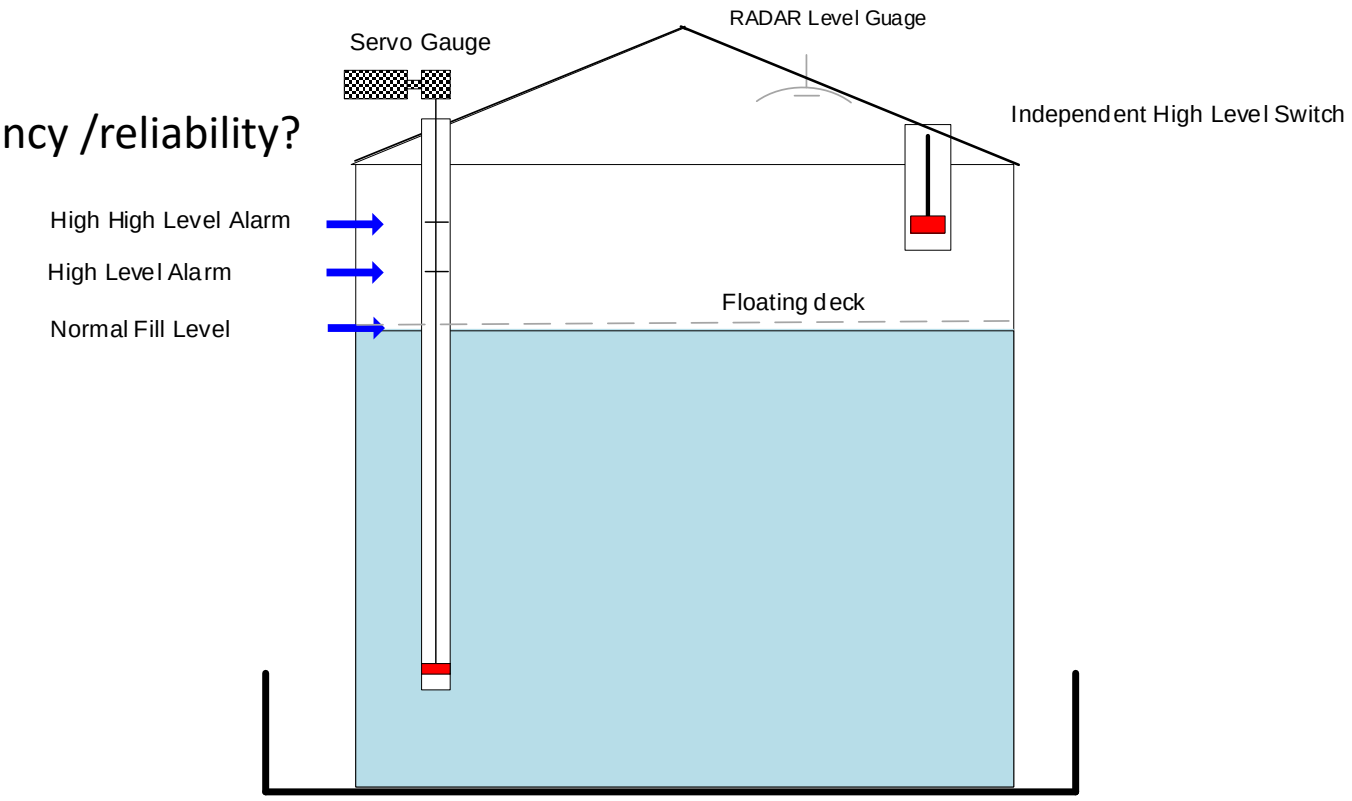
Lagging indicators:

- No. times a tank is overfilled / year
- % overfills / year
- No. of fires / explosions due to overfilling

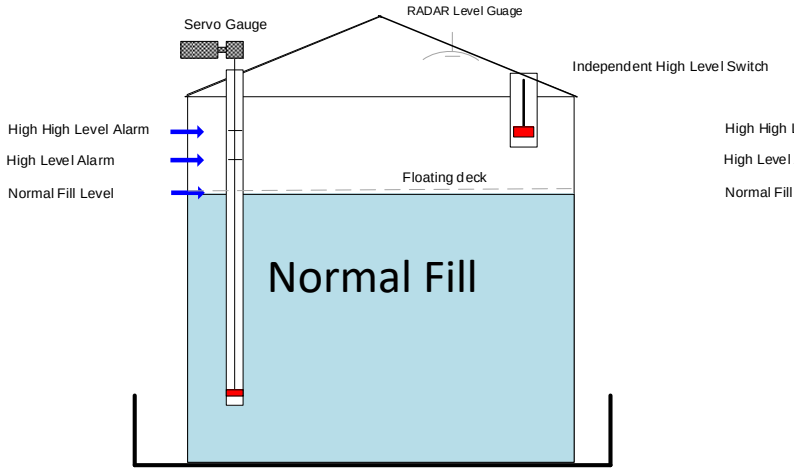


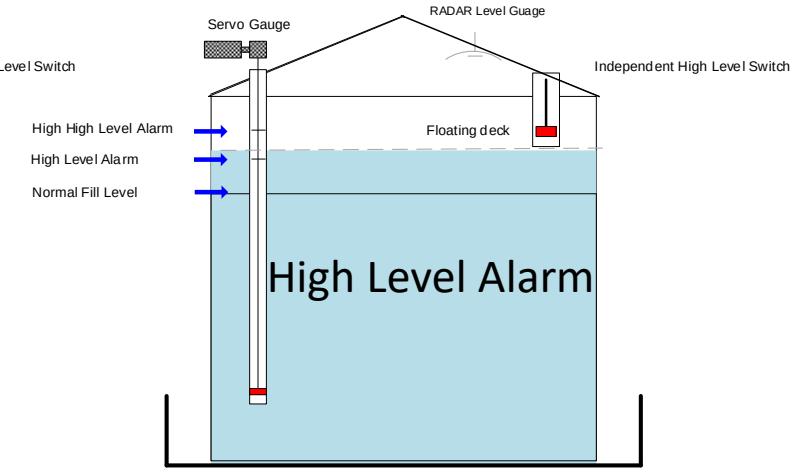
KPIs for tank overfilling - Key questions for lagging indicators

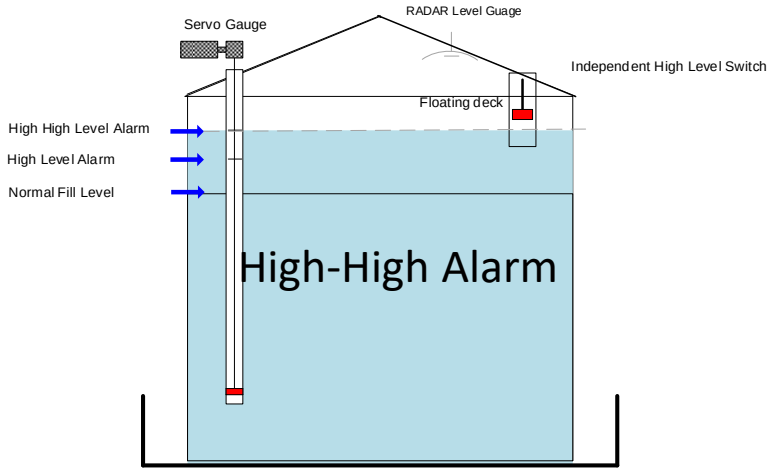
- Is there agreement on the desired ‘outcome’ or what the wrong outcome is?
- Can the outcome be detected and recorded?
- Is there any tolerance on the outcome?
- What metric should be used?
- What is the source of the data / accuracy / frequency /reliability?



What is the ‘adverse outcome’ for ‘tank overfilling’?

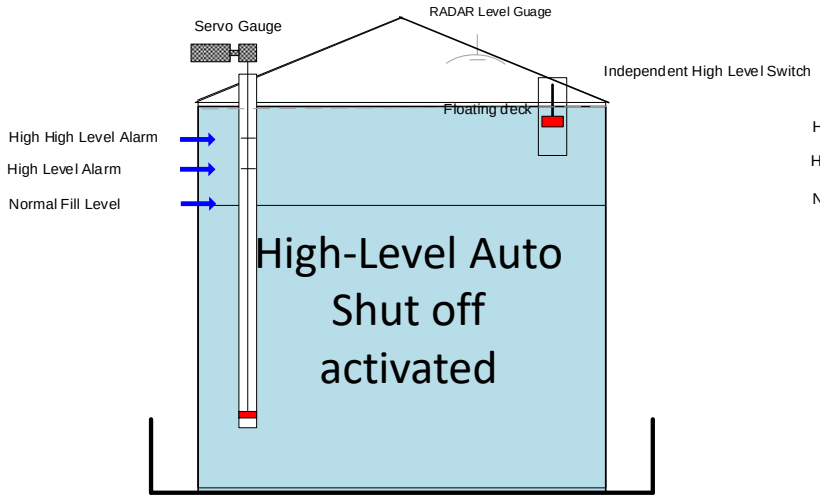


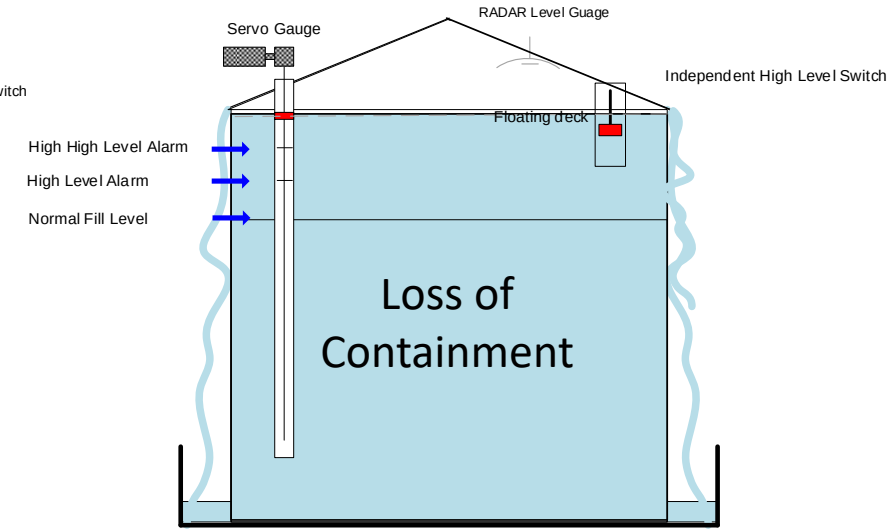


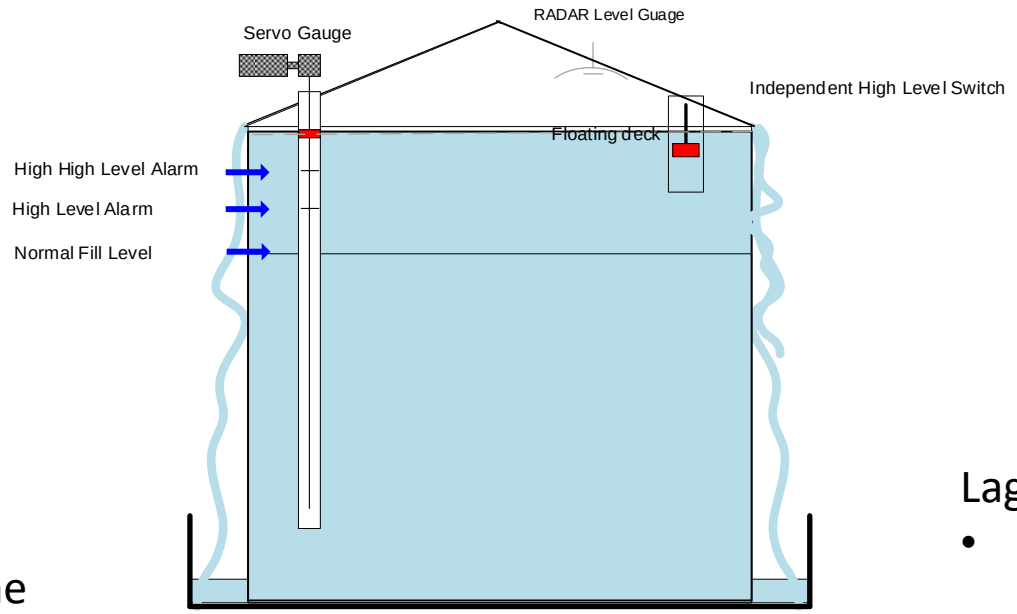


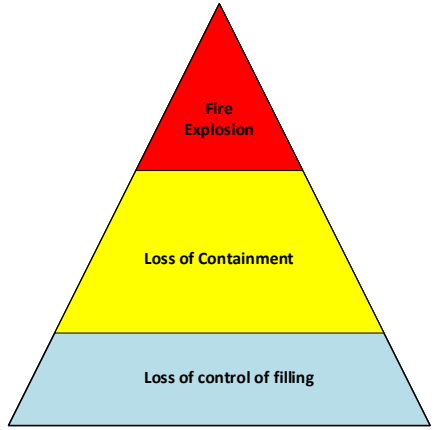
Setting the Adverse Outcome.

What does ‘overfilled’ mean?







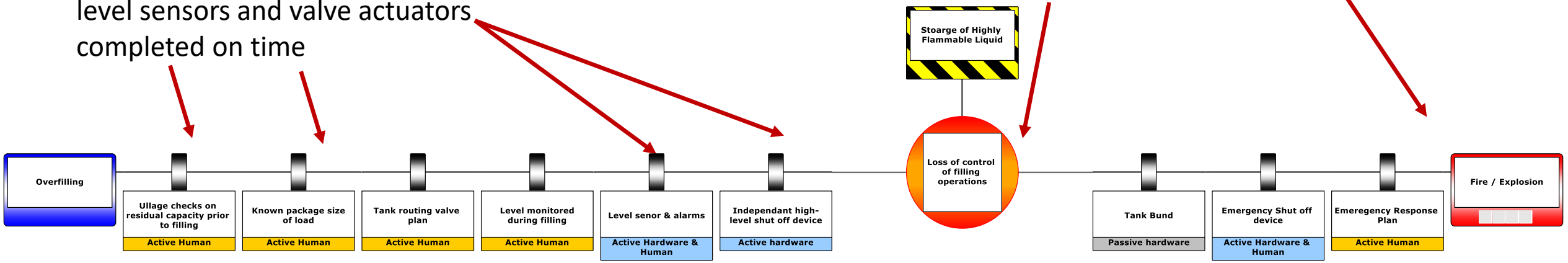


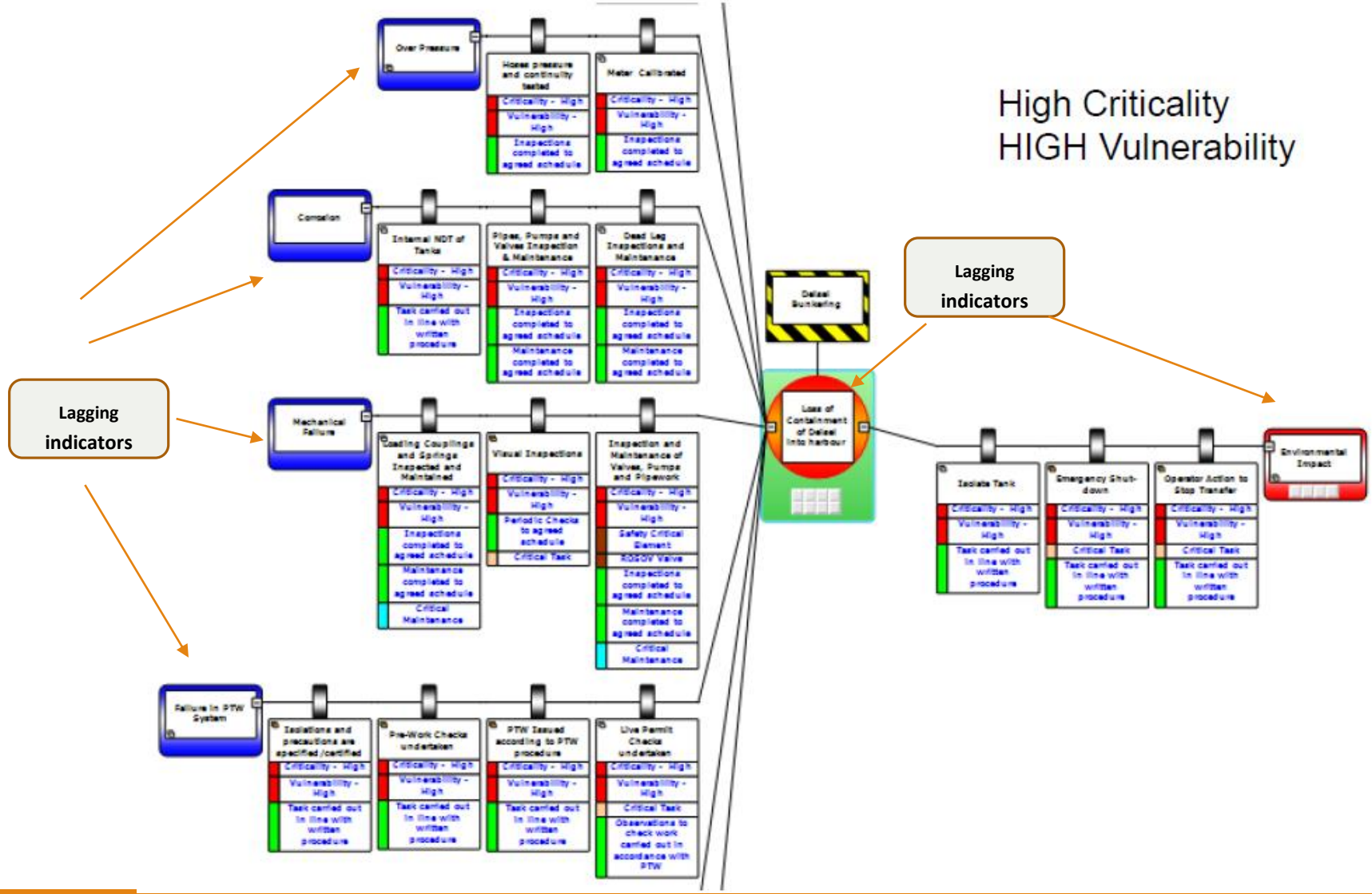
Leading indicators:

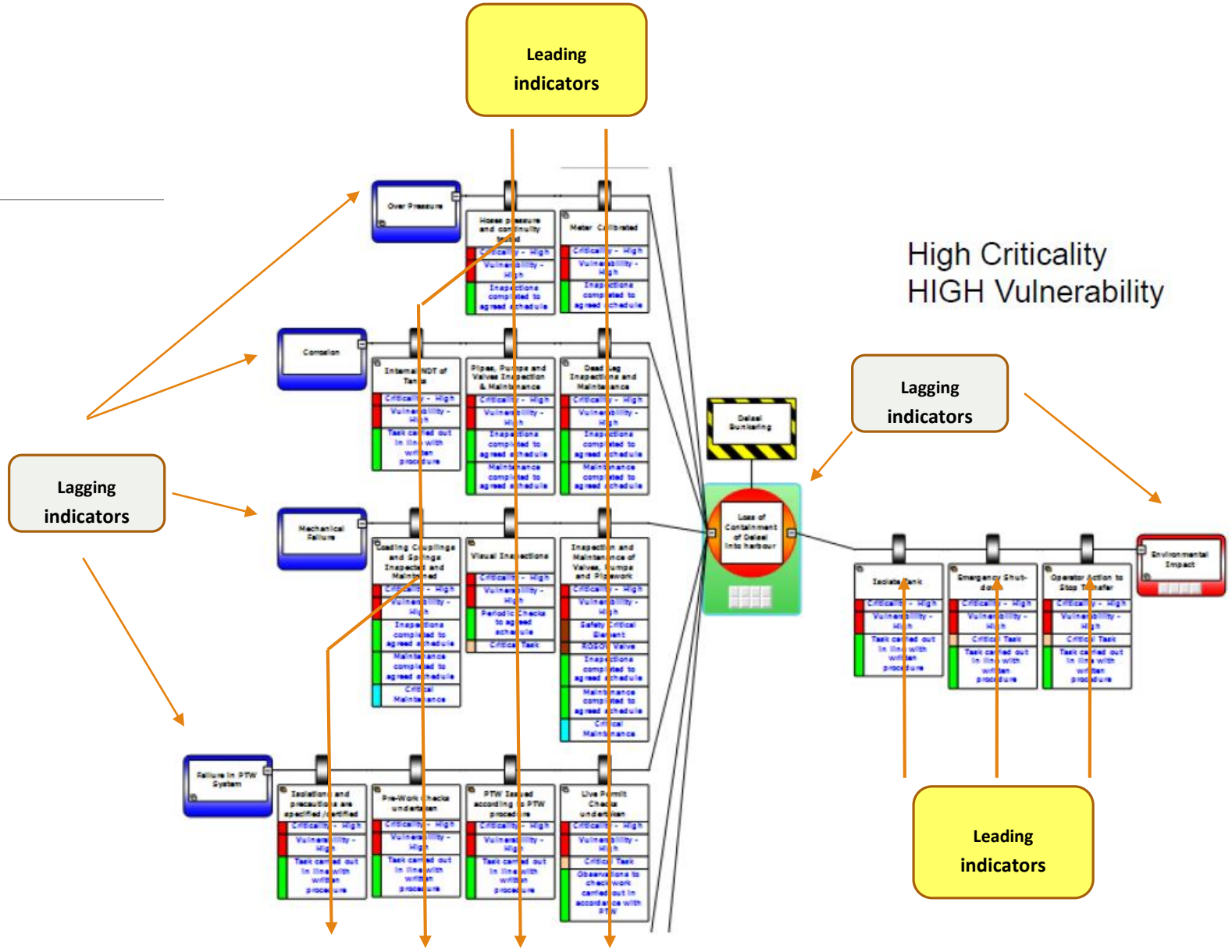
- % times ullage calculation done correctly
- %. times the tank routing valves are set correctly
- % of inspections & calibration of level sensors and valve actuators completed on time

Lagging indicators:

- No. times there is a loss of control of filling
- % los of control of filling / year
- No. of loss of containments / year
- No. of fires / explosions due to overfilling




High Criticality
HIGH Vulnerability
Lagging indicators
Lagging indicators
Over Pressure
Hoses pressure and continuity tested
Meter Calibrated
Corrosion
Internal NDT of Tanks
Pipes, Pumps and Valves Inspection & Maintenance
Dead Leg Inspections and Maintenance
Mechanical Failure
Loading Couplings and Springs Inspected and Maintained
Visual Inspections
Inspection and Maintenance of Valves, Pumps and Pipework
Failure in PTW System
Isolations and precautions are specified /certified
Pre-Work Checks undertaken
PTW Issued according to PTW procedure
Live Permit Checks undertaken
Diesel Bunkering
Loss of Containment of Diesel into harbour
Isolate Tank
Emergency Shut-down
Operator Action to Stop Transfer
Environmental Impact


Leading indicators
Lagging indicators
Lagging indicators
Leading indicators
High Criticality
HIGH Vulnerability

Setting KPIs for process safety management

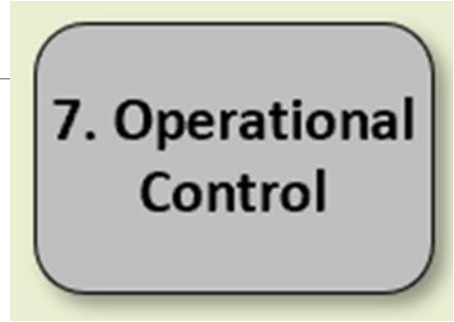
Measure in as many of the 14 elements as you can

Set lagging indicators against the outcome of each element – an incident or loss of control cause by failure in:

- hazard identification
- Risk assessment
- Plant / process design
- Etc. etc

Choose leading indicators to show the most vital activities are being followed to deliver the desired PSM element outcome

Setting KPIs for process safety management



Example

7. Operational Control

Outcome: The plant and processes are operated and maintained in a safe condition and sufficient safety margins are maintained at all times. Plant integrity is not degraded during start-up or operation and processes can be safely shut down or brought under control in an emergency.

Lagging KPI: No. of times the designated safe operating limit of processes are met or exceeded during start up or shut down.

Counted on occurrence. Presented as % of start ups or as a frequency per hours worked, etc.

Leading KPI: Whether the correct start-up / shut down sequence is set out clearly, understood by process operators, and always followed.

Counted by sampling and reviewing start up / shut down processes. Presented as % of start ups reviewed within the routine sample / check.

Not all KPIs are Equal

- Measuring performance of process safety systems is important but it's measuring the right things that give you the best insight into early failures or challenges to the integrity of containment system is vital.
- The most important KPIs are those that provide an insight into whether the systems that protect against the challenges to integrity are degraded.
- Act on the first signs of adverse degradation eg the Process Indicators.

Not all KPIs are Equal

Challenges to Integrity Indicators

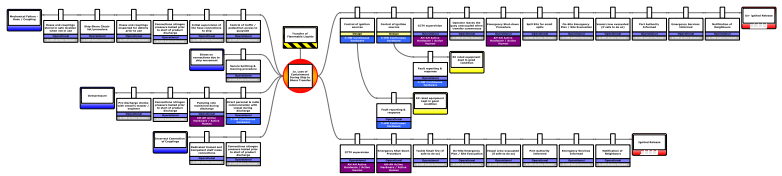
- Overfilling
- Over / Under Pressure
- Over / Under Temperature
- Mechanical Wear & Tear
- Corrosion
- Erosion
- Impact
- Stability
- Stress / fatigue
- Human Error

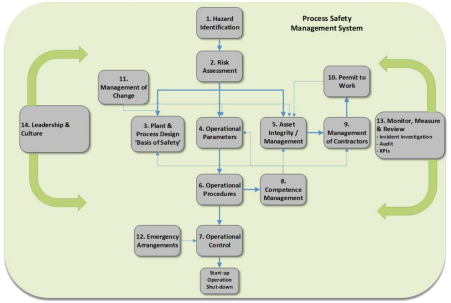
PSM Elements Indicators

- Hazard ID
- Risk Assessment
- Plant Design
- Operating Parameters
- Operating Procedures
- Operational Control
- Competence Management
- Management of Contractors
- Permit to Work
- Management of Change
- Emergency Arrangements
- Monitoring, Measuring & Review
- Leadership & Culture

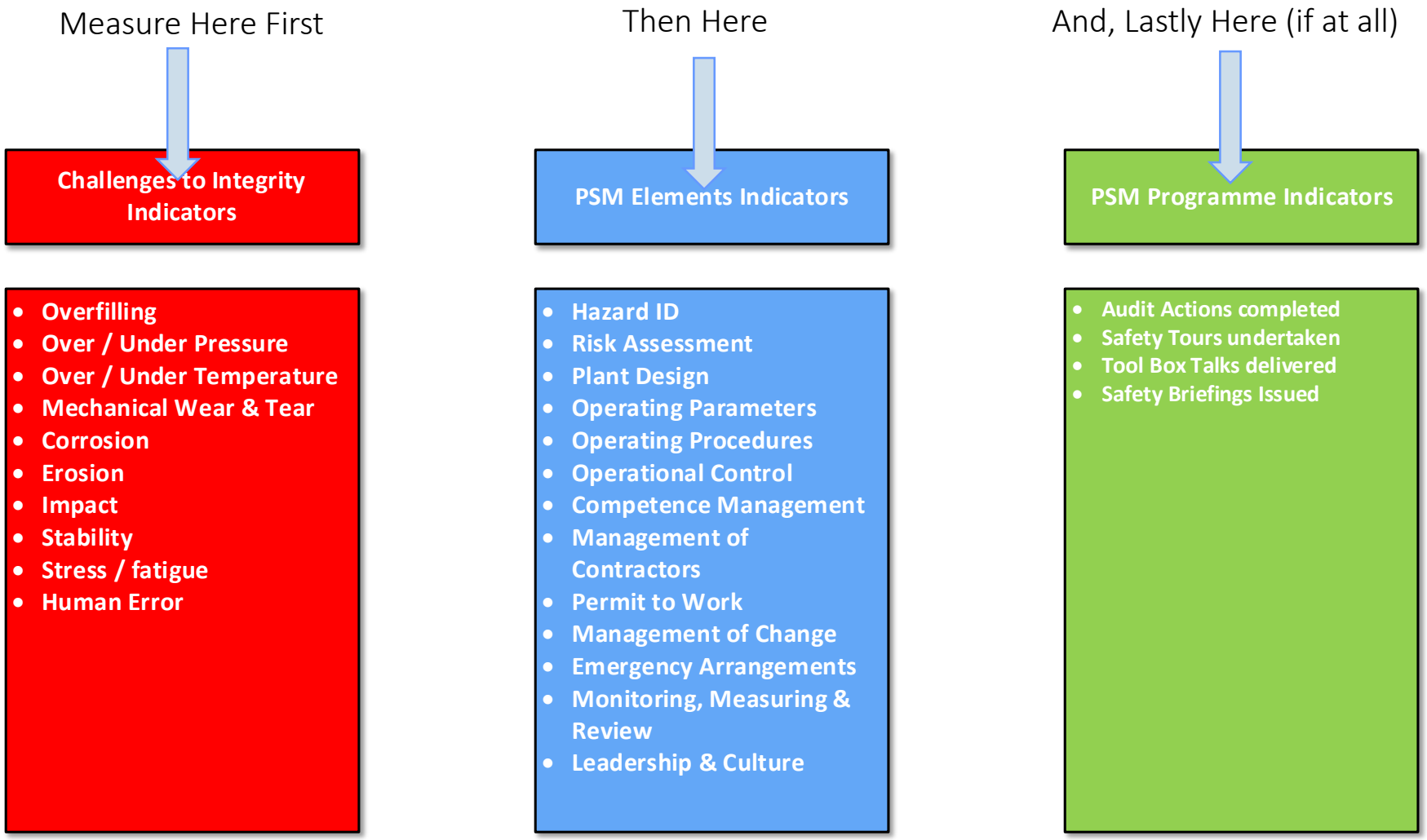
PSM Programme Indicators

- Audit Actions completed
- Safety Tours undertaken
- Tool Box Talks delivered
- Safety Briefings Issued

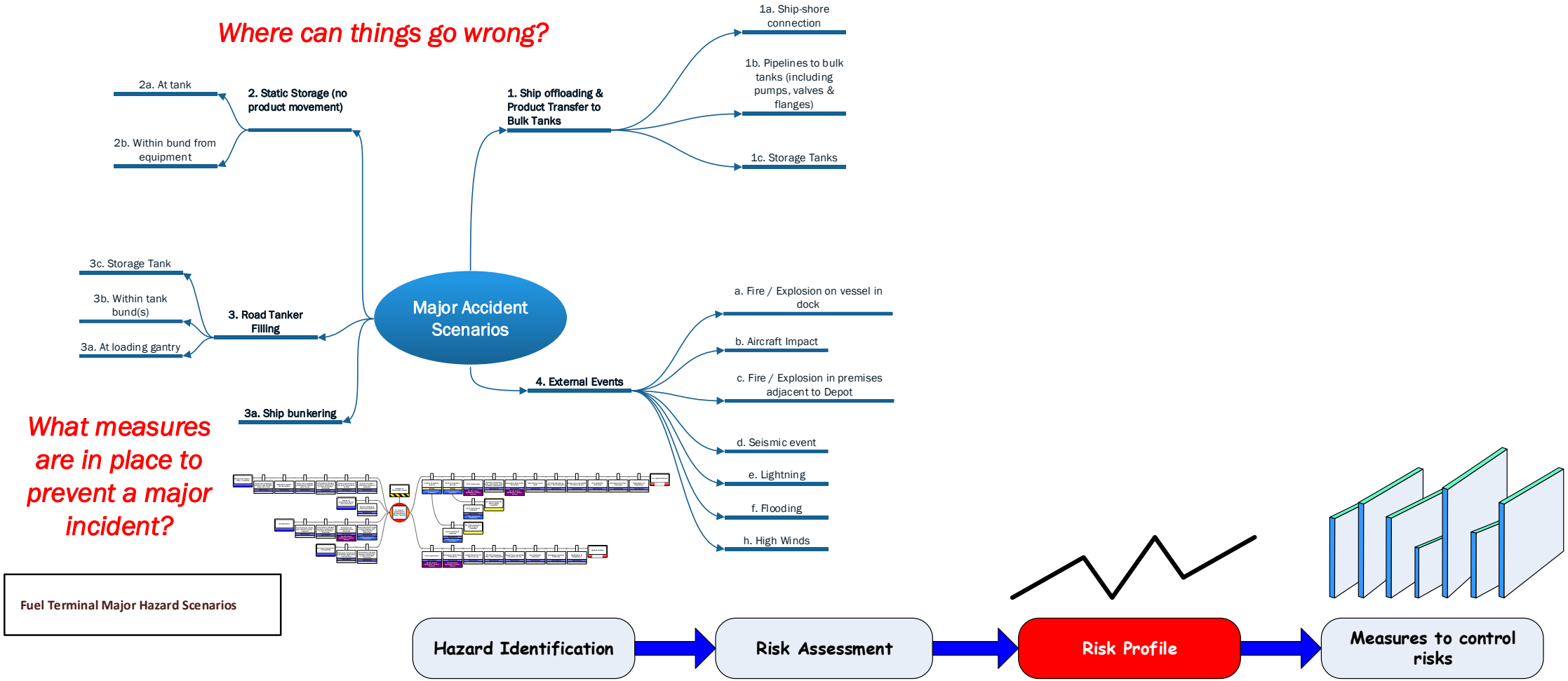




Not all KPIs are Equal



KPIs should reflect the risk profile of the facility



Thank you
Any Questions?

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