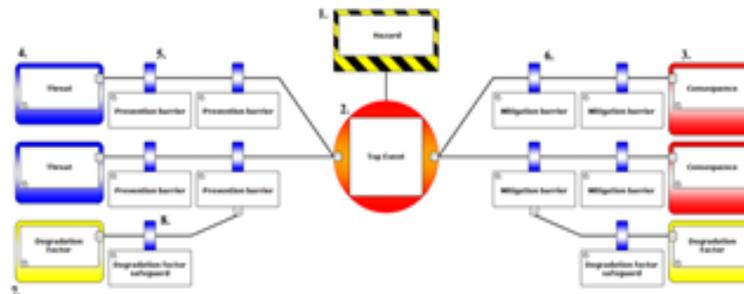


'Bow Ties in Risk Management'



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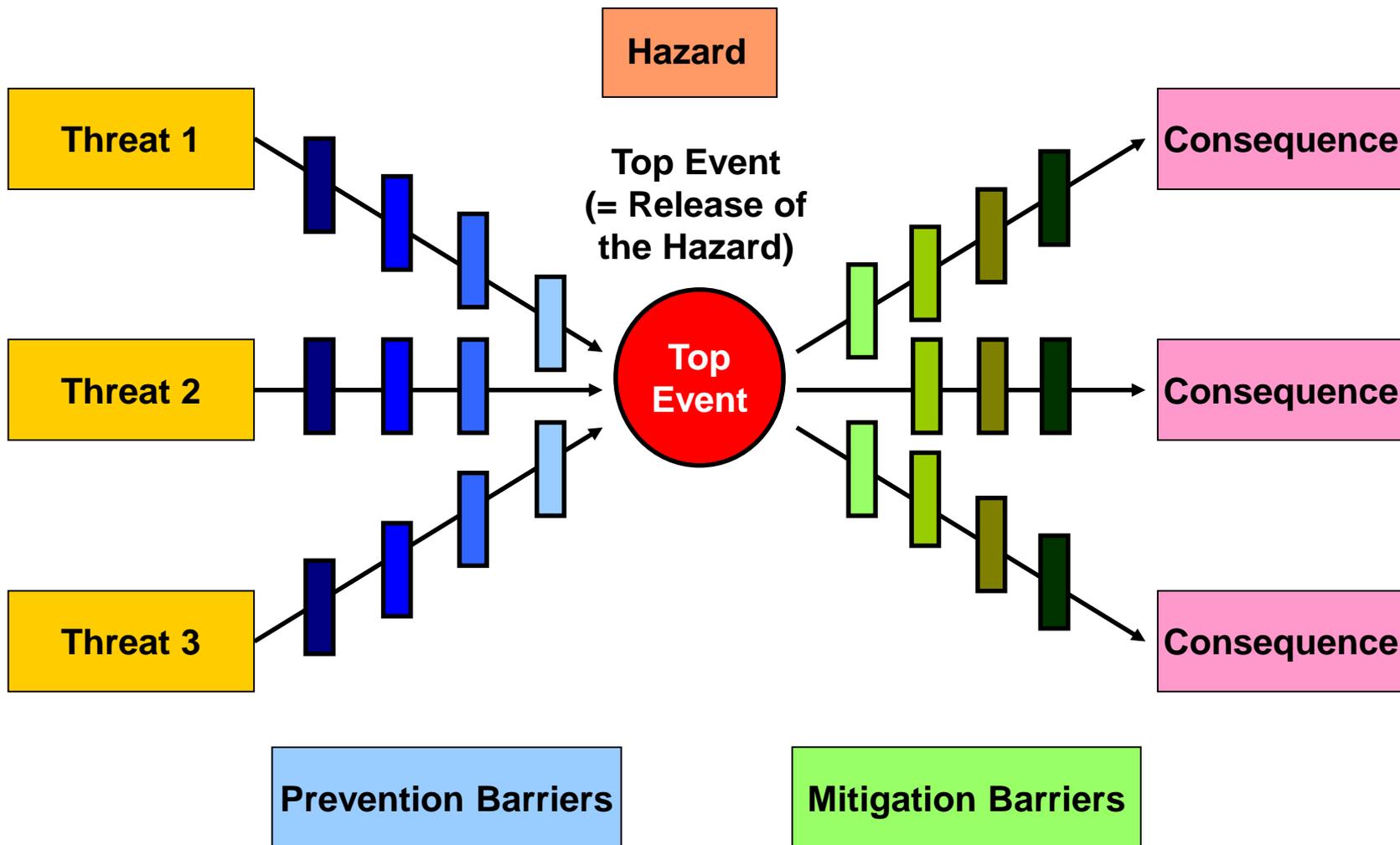


“The Global Community Committed to Process Safety”

To protect people, property and the environment by bringing the best process safety knowledge and practices to industry, academia, the governments and the public around the world through collective wisdom, tools, training and expertise



The EI's purpose is to develop and disseminate knowledge, skills and good practice towards a safe, secure and sustainable energy system. It informs policy by providing a platform for debate and scientifically-sound information on energy issues. In fulfilling the EI's mission, its Technical Work Program addresses the depth and breadth of the energy sector, from fuels and fuels distribution to health and safety, sustainability and the environment. This program provides cost-effective, value-adding knowledge on key current and future issues affecting those operating in the energy industry, both in the UK and internationally.

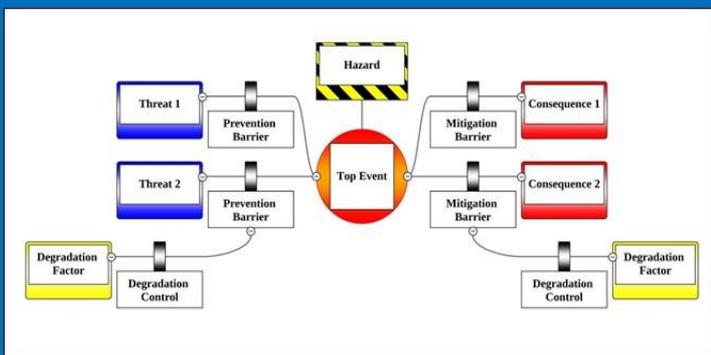


A good bow tie diagram summarises how a hazard is managed, in one understandable picture

- The diagram is shaped like a bow tie, creating a clear differentiation between the proactive (Prevention) and reactive (Mitigation) side of risk management.
- Very successful in helping to understand and communicate risks
- Used for process and non-process industry risks
- Aids understanding and management of barriers
- Now widely used by many companies
- But...

BOW TIES IN RISK MANAGEMENT

A Concept Book
for Process Safety



Anticipated book publishing

Q3 2018



- **Confusion about who (and what) bow ties are for**
- **No generally accepted methodology and terminology**
- **Some typical problems with existing bow ties:**
 - Structural errors: e.g. degradation controls shown as barriers
 - Lack of rigour in constructing bow tie elements:
 - Hazard or Top Event description vague, or confused with Consequence
 - Incomplete barriers: barrier elements listed as ‘the barrier’
 - Management System elements included as ‘barriers’
 - ‘Human and Organisational Factors’ confused and ineffective
 - **Unfair criticism that bow ties over-simplify incident causation**

What the book delivers

- Challenges to bow tie developers... (and suggested answers to these)
 - **Why** and **for Whom** are they making them?
 - **How** are they making them? (who should be involved?)
- Improved understanding of what constitute **effective barriers** and **barrier degradation** mechanisms
- Clearer portrayal of **degradation controls** and linkage to the management system and leadership
- Better treatment of '**Human and Organizational Factors**'
- Opportunity to standardize the industry approach and terminology
- Examples of poor and good practice
- Combined thoughts of a large number of experts – from Oil & Gas, Chemicals and other industries

Project Team Chair: Kiran Krishna, Shell
Co-Chair: Mark Scanlon, Energy Institute
Vice-Chair: Tim McGrath, Genentech (ex Chevron)
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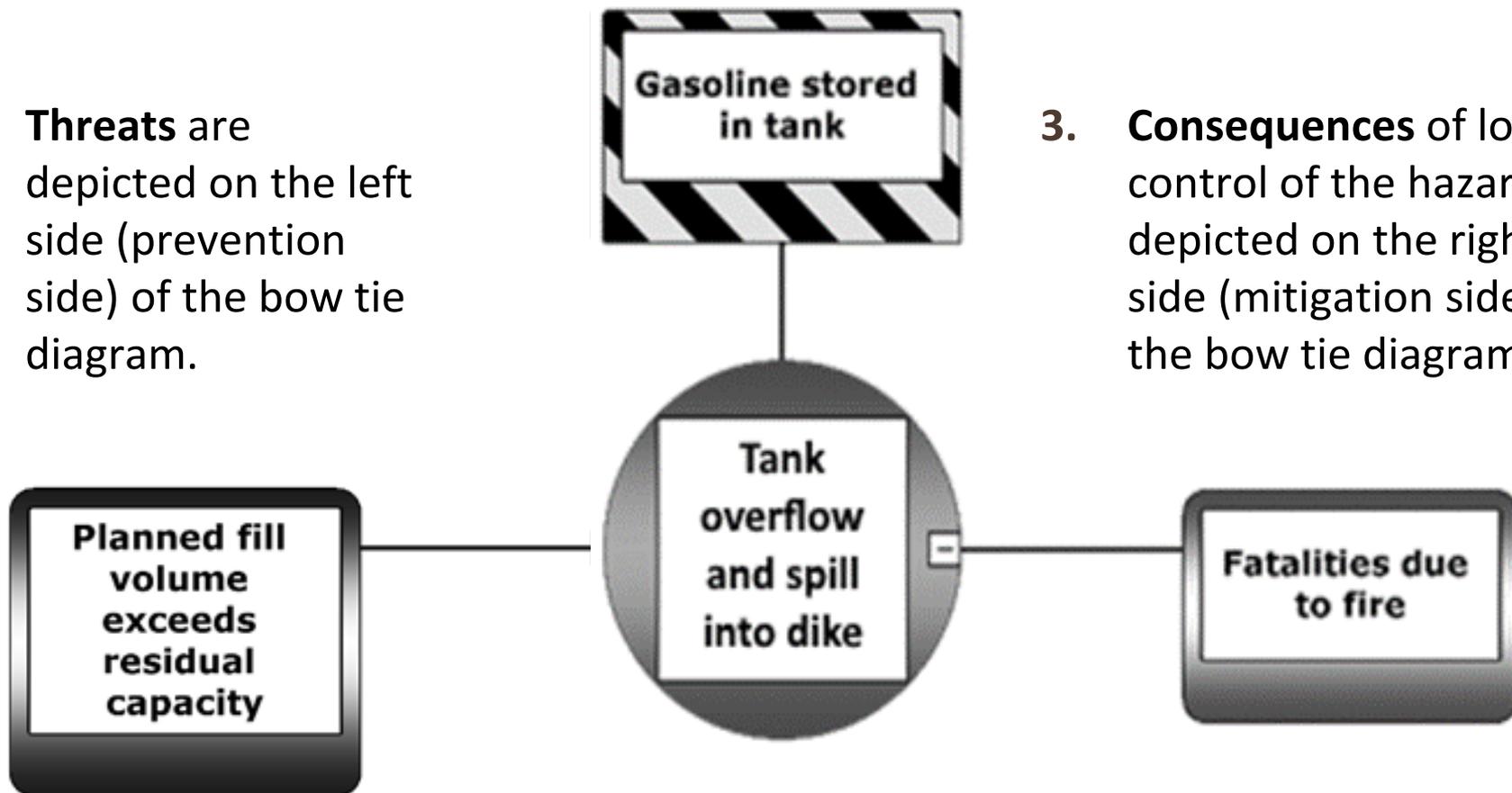
UKPIA Major Hazards WG
 H&SL
 API RP 75 revision WG
 COMAH, EA England
 ExxonMobil - PS & Reliability
 Prof Patrick Hudson
 Trish Kerin (ICHEME SC)
 Dr Sam Mannan MKOPSC
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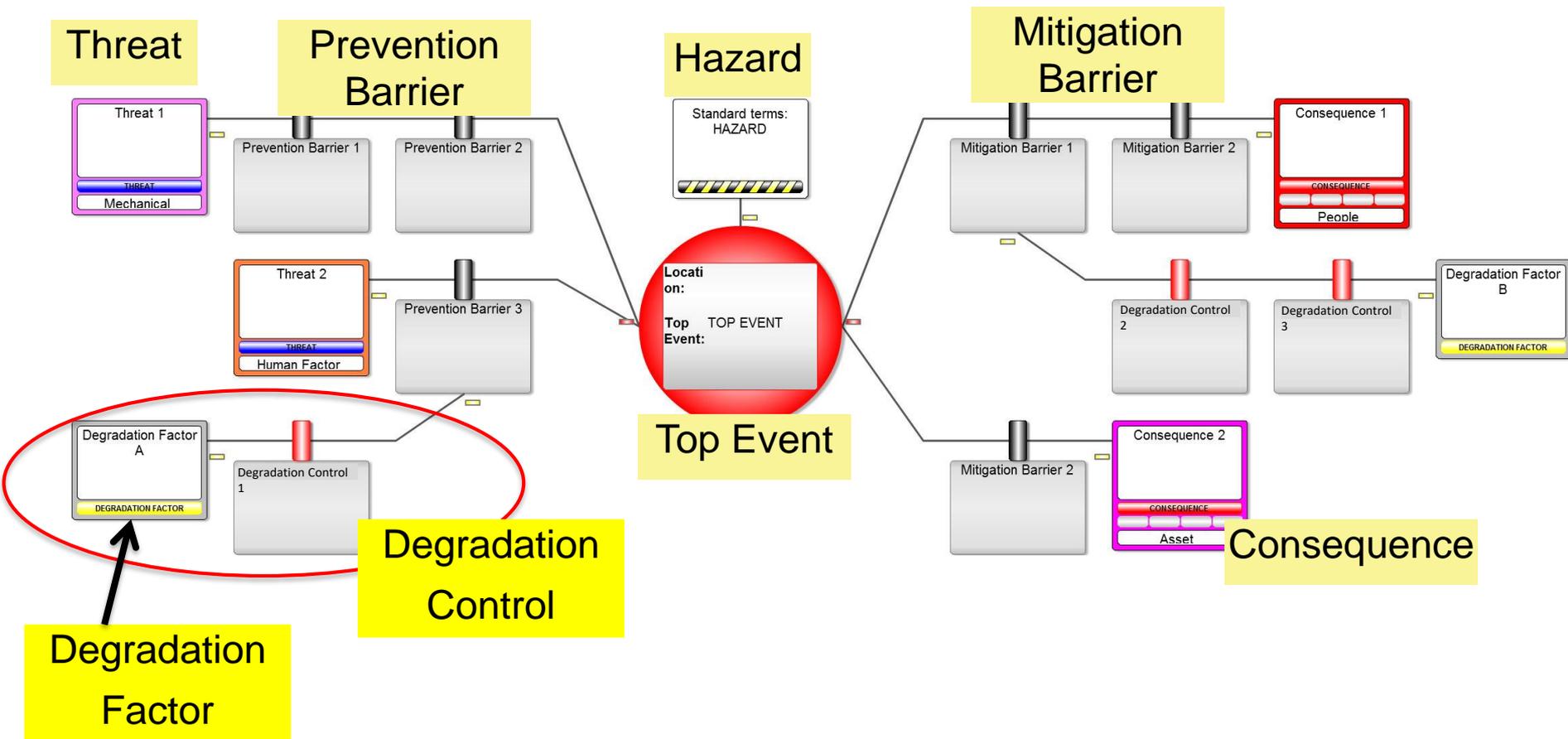


1. **Hazard** The bowtie starts with the hazard
2. **Top Event** being the loss of control of the hazard (the centre of a bowtie)

4. **Threats** are depicted on the left side (prevention side) of the bow tie diagram.

3. **Consequences** of loss of control of the hazard are depicted on the right side (mitigation side) of the bow tie diagram.





Barrier:

- A risk reduction measure that **on its own** can prevent a threat developing into a top event (prevention side)
...or can mitigate the consequences of a top event once it has occurred (mitigation side)
- Must be effective, independent and auditable
- Active barriers must have all 3 elements of Detect, Decide, Act

Effective

- *Prevention* barrier: capable on its own of preventing a threat developing into the top event
- *Mitigation* barrier: capable of reducing consequences

Independent

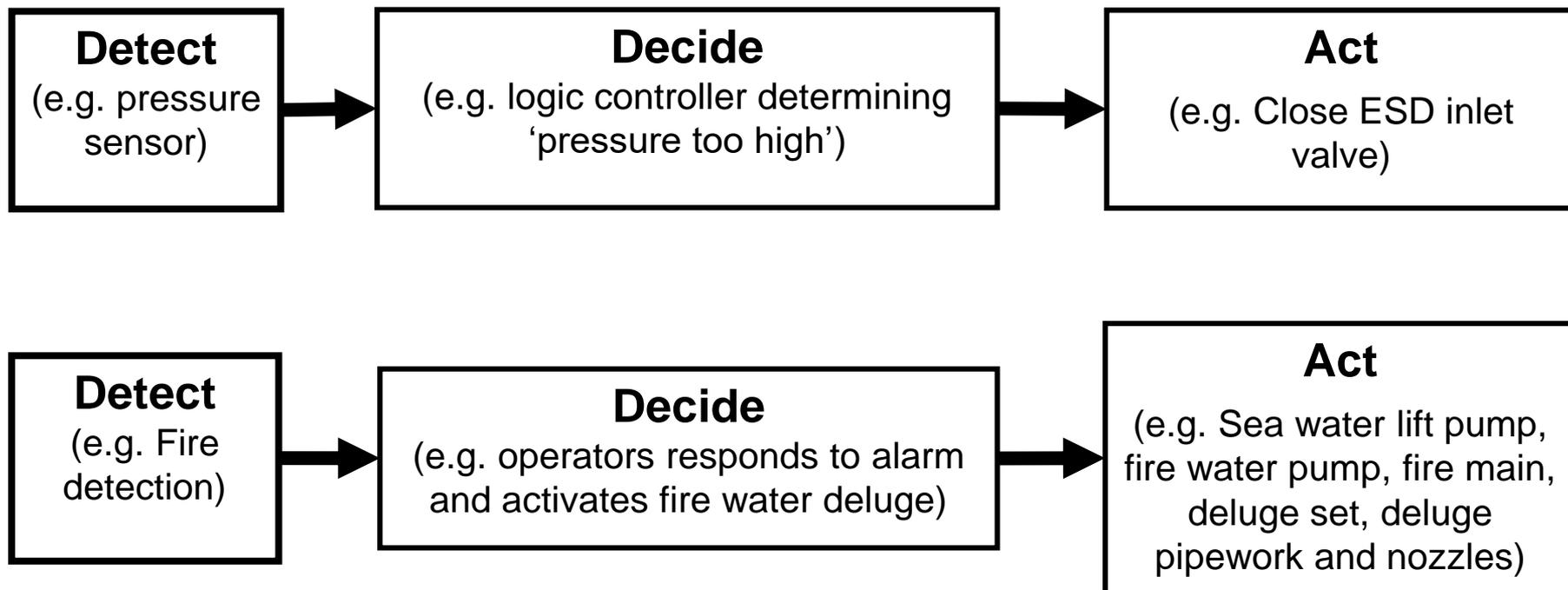
- no common failure modes with other barriers

Auditable

- There is a means to check that it works
- There are performance standards for functionality

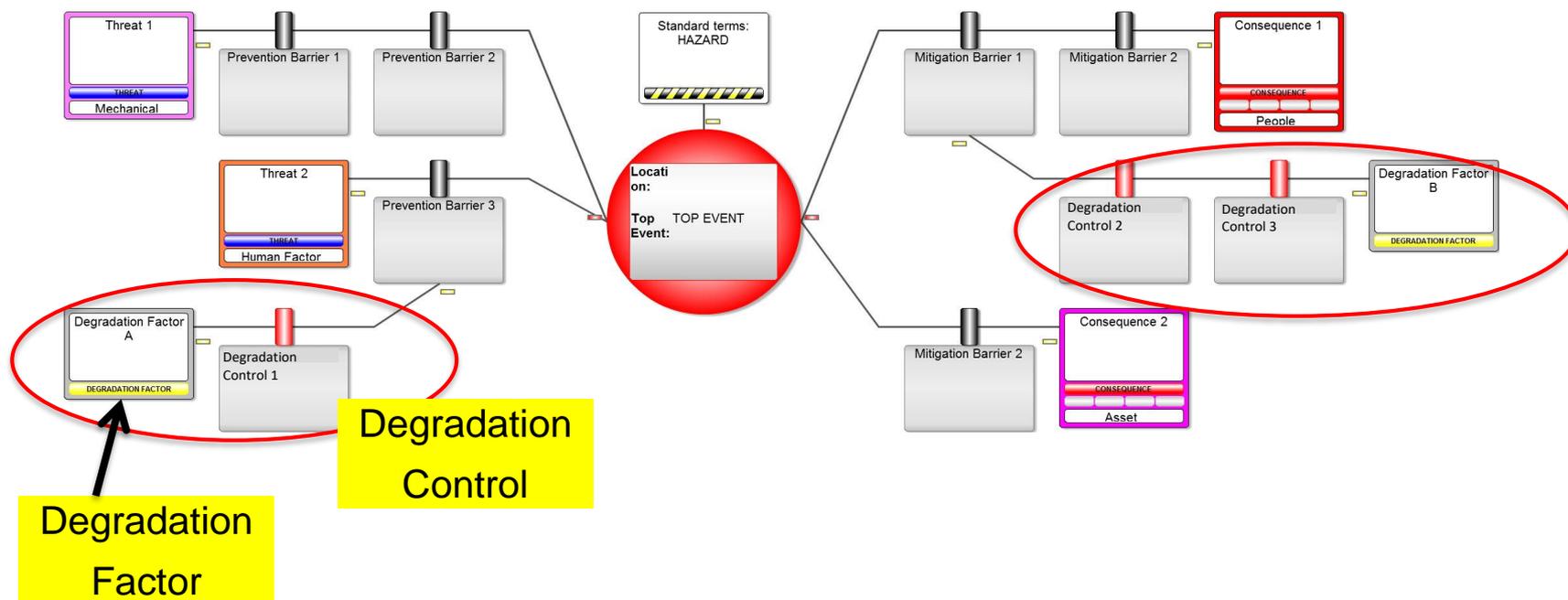
Barrier:

- Active barriers must have all 3 elements of Detect, Decide, Act

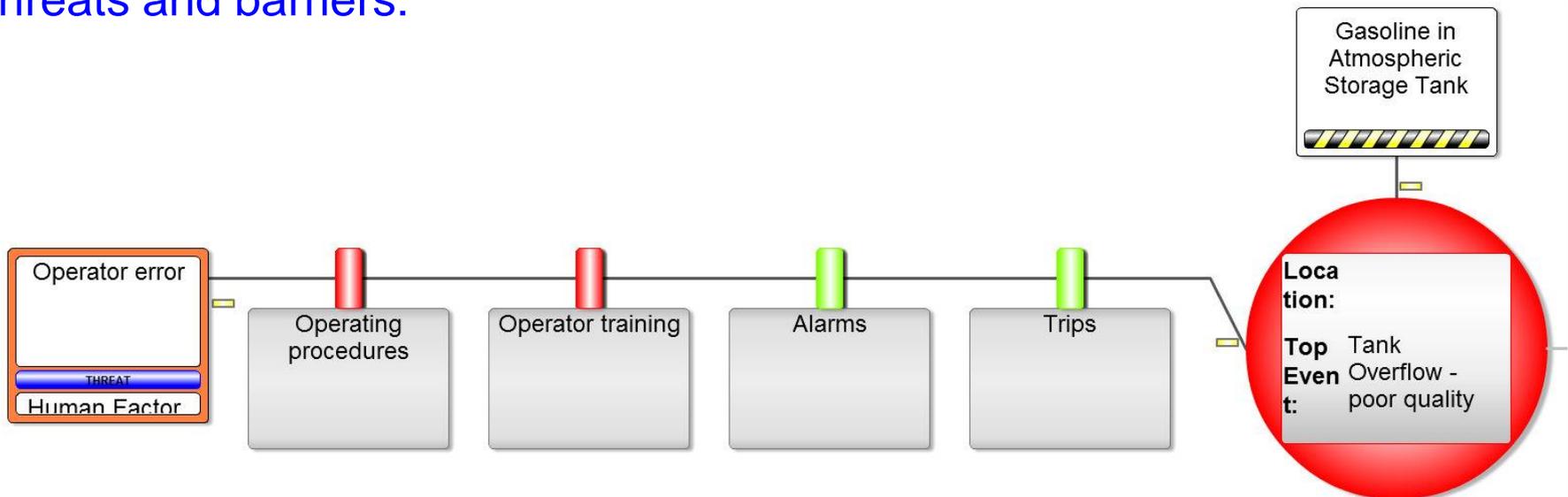


Degradation Control:

- Similar to barrier, but only appears on **Degradation Pathways**
- Does not need to meet full criteria for barrier



Historically, some bow ties have been developed with vague descriptions of threats and barriers:

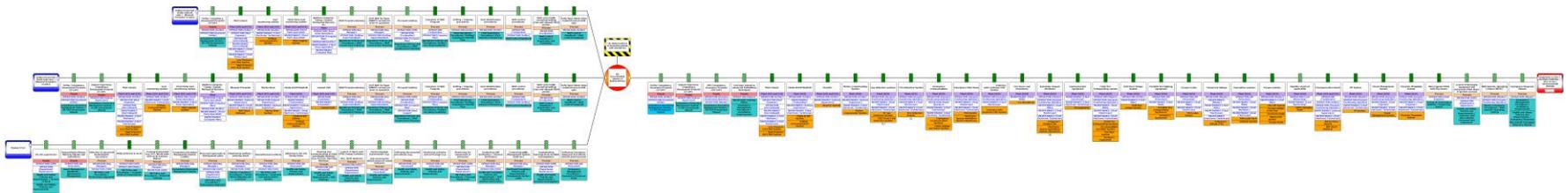


But

- How can the “human error” threat lead to the top event (if all barriers fail)?
- What are the Detect, Decide, Act components of these barriers?

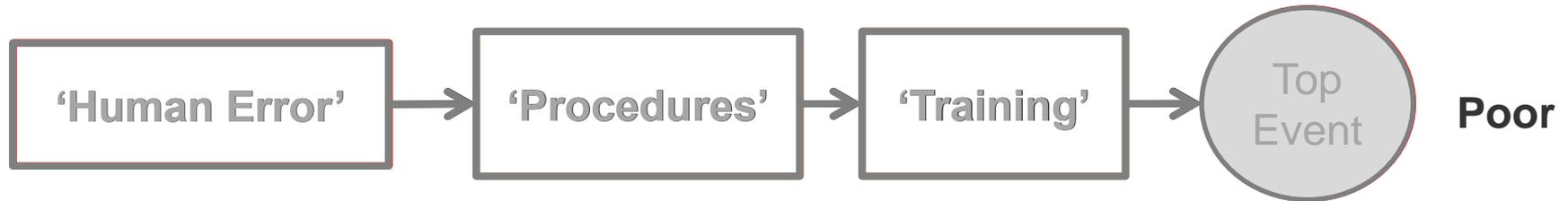
Bow ties do not work without rules for barriers

- Including everything connected with the top event does not help the understanding of barriers or risk management
- Example from a drilling contractor 20 prevention and 32 mitigation barriers!



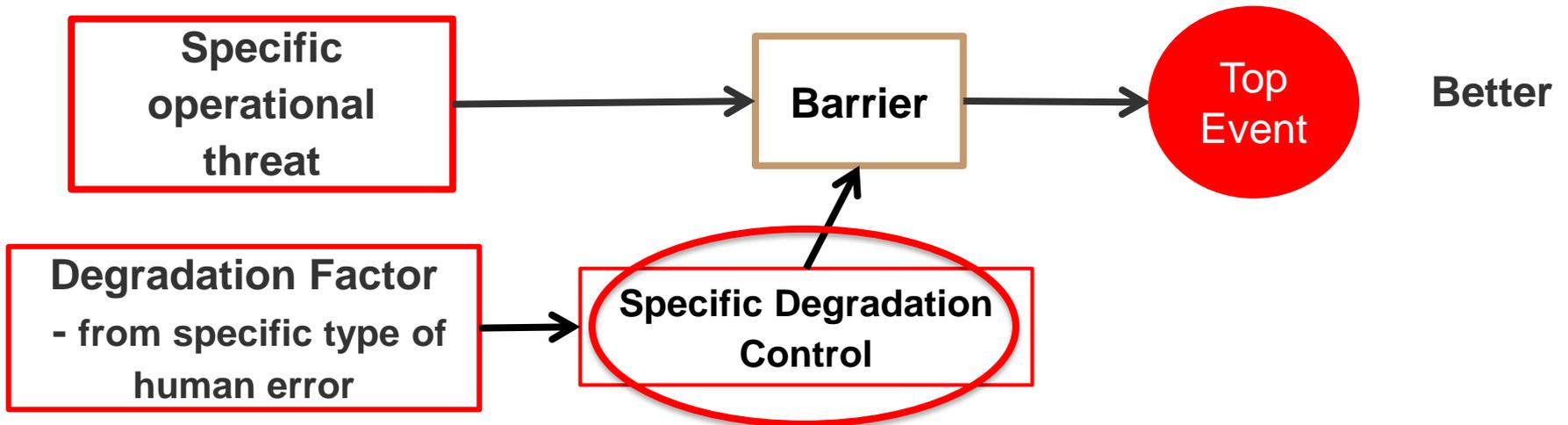
- All these are probably important, but most will be **degradation controls** supporting a small number of actual barriers

Many current bow ties show Humans as threats



Human Error is correctly shown as a Degradation Factor

Then specific controls can be incorporated, to maintain the barrier strength



Human Error

Human error is not a threat leading to a top event, but rather something that could defeat a barrier that is protecting against that top event

Whenever someone is inclined to put ‘human error’ as a threat, they should challenge themselves by asking:

"what is the barrier or degradation control that this error would defeat"?

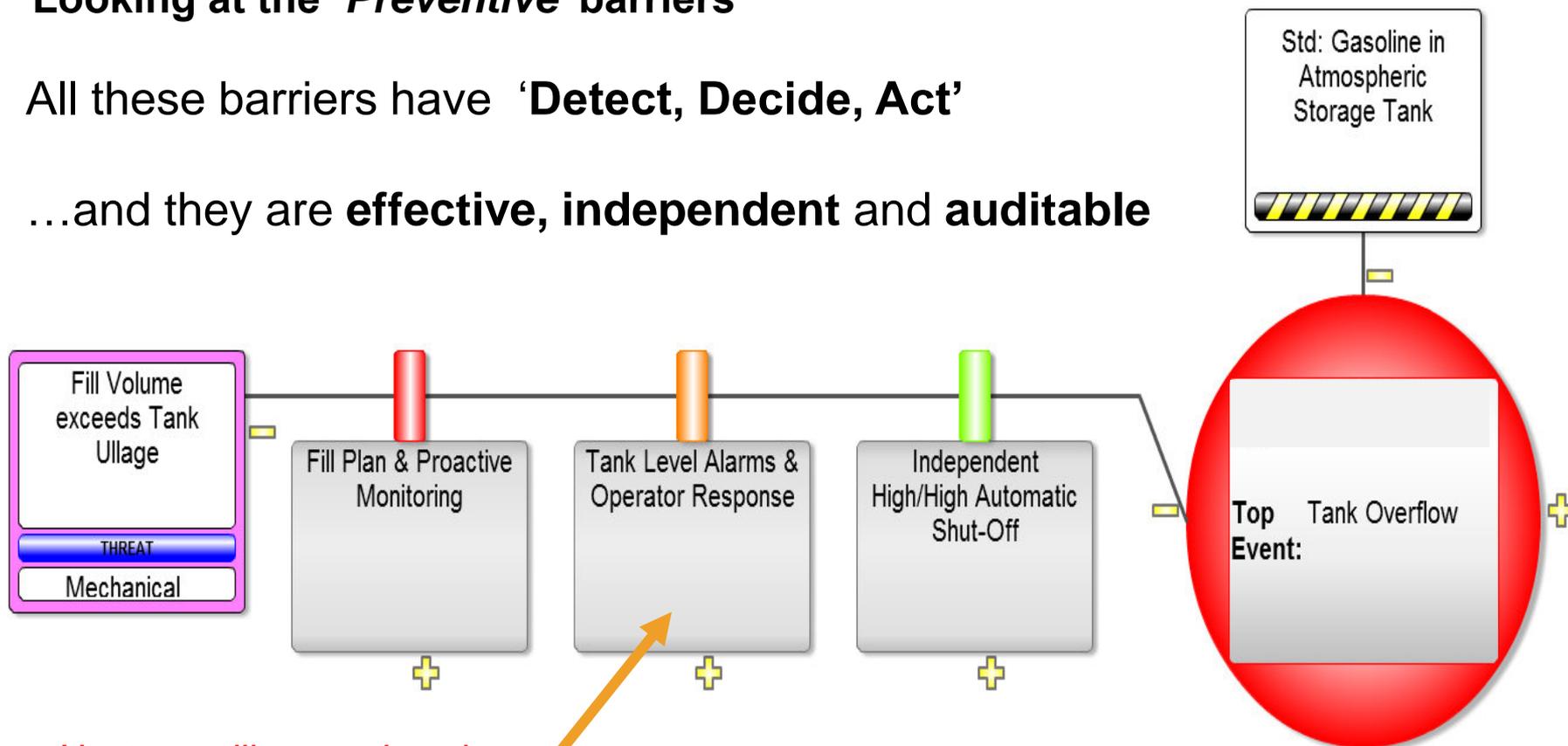
EXAMPLE: Buncefield-type bow tie



Looking at the 'Preventive' barriers

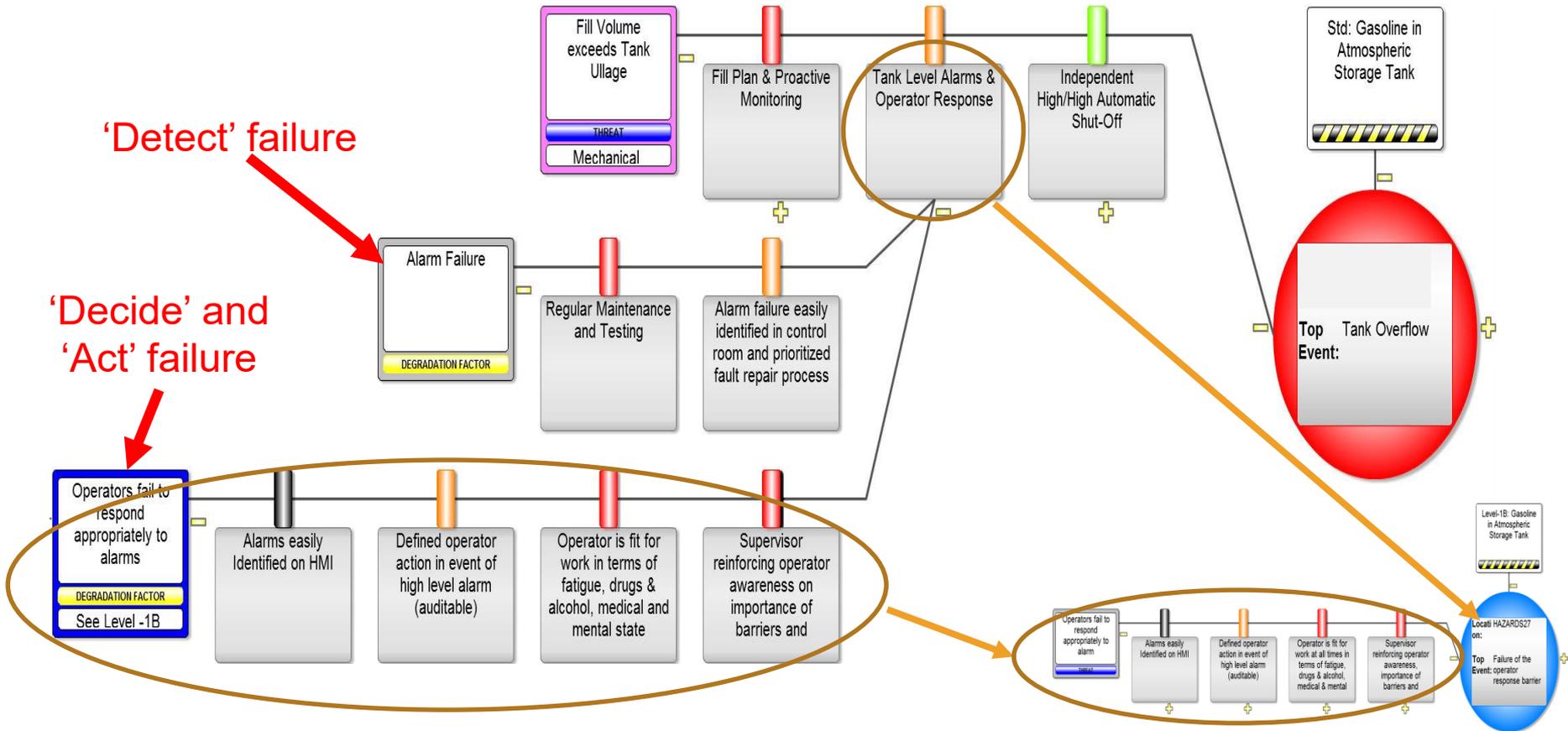
All these barriers have 'Detect, Decide, Act'

...and they are **effective, independent and auditable**



Next we will expand to show the degradation factors for this barrier

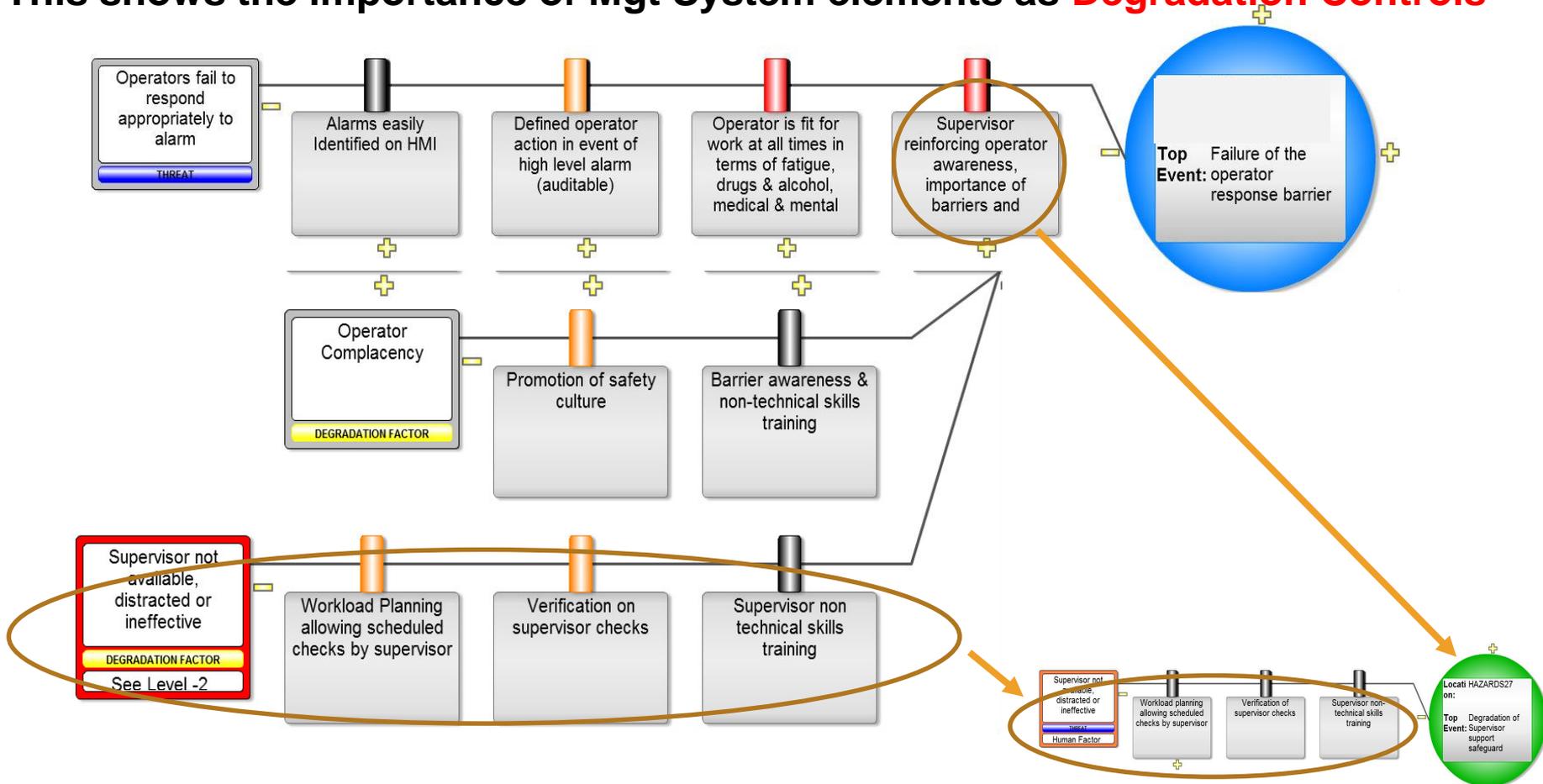
Degradation of barrier: 'Tank Level Alarms & Operator Response'



This degradation leg can be expanded to become an **Extension level 1 bow tie**

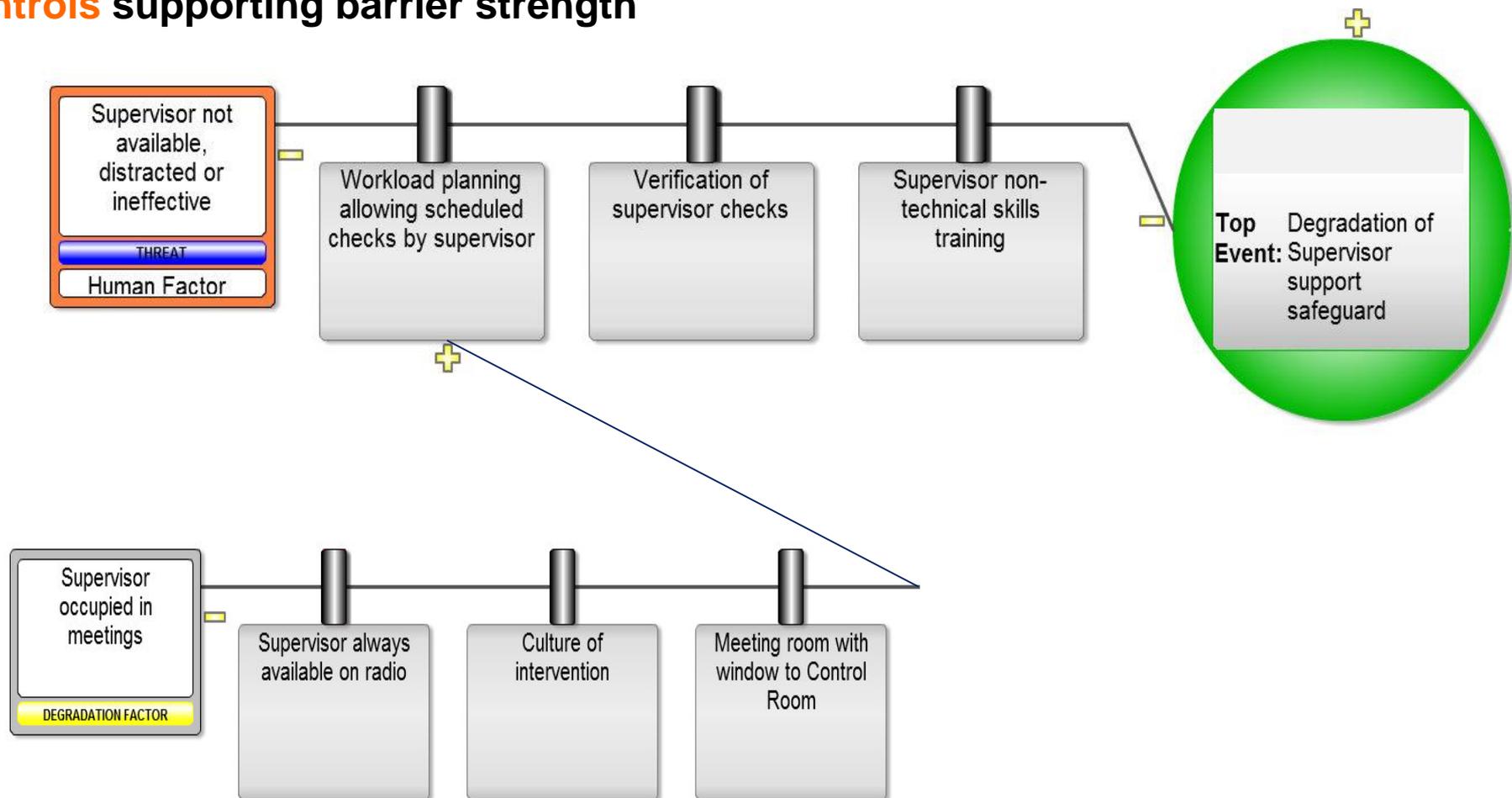
Extension Level 1 bow tie

This shows the importance of Mgt System elements as **Degradation Controls**



This **deeper-level** degradation leg could now be further expanded into a **Level 2 bowtie**

Extension Level 2 bow tie – showing how **good practices** are also **degradation controls** supporting barrier strength



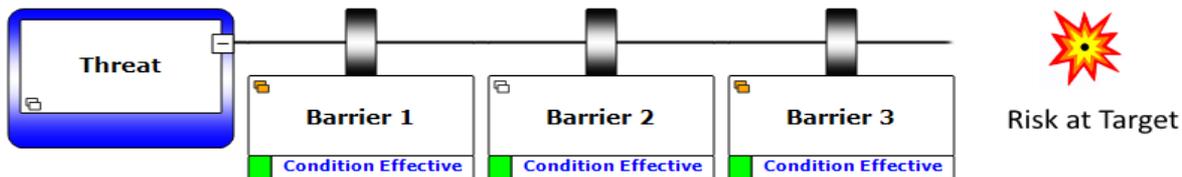
Bow Ties can improve *risk analysis* and *definition of barriers*:

- Determining potential accident pathways
- Assessing sufficiency, effectiveness and diversity of type of barriers
- Barrier types:
 - **passive hardware** eg bund wall
 - **active hardware** eg Safety Instrumented Systems
 - **active hardware + human** eg alarm + operator action
 - **active human** eg operator observation round + action
- Special Type
 - **continuous hardware** eg ventilation system
- Analysing potential barrier degradation mechanisms (factors) and their controls

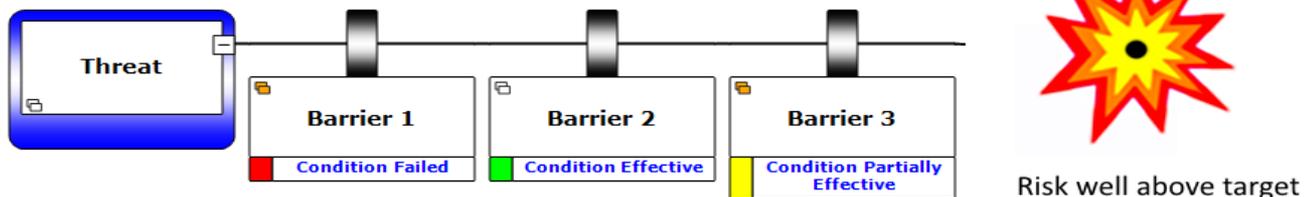
Bow Ties can improve *implementation* of barriers:

- Help understand the hazards and how they are controlled
 - Operators, Managers, Regulators, others...
- Improve barrier ownership
- Prioritize audit, inspection and maintenance of barriers
- Help manage cumulative risk:
...what is the **current condition** of barriers compared with the design intent?

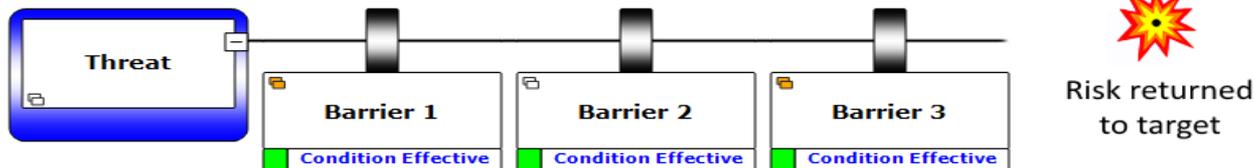
Design Basis



During Operations

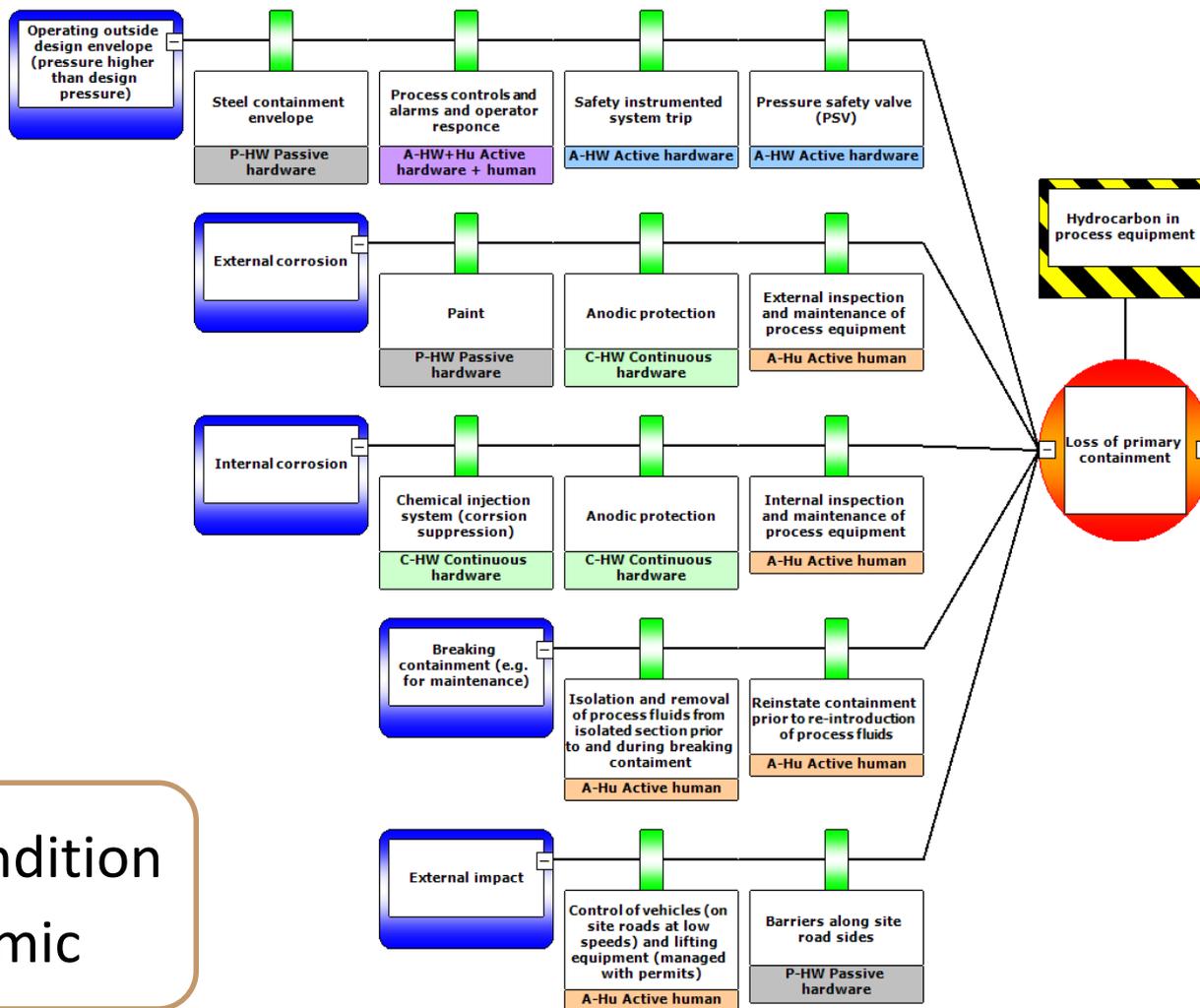


With barrier management

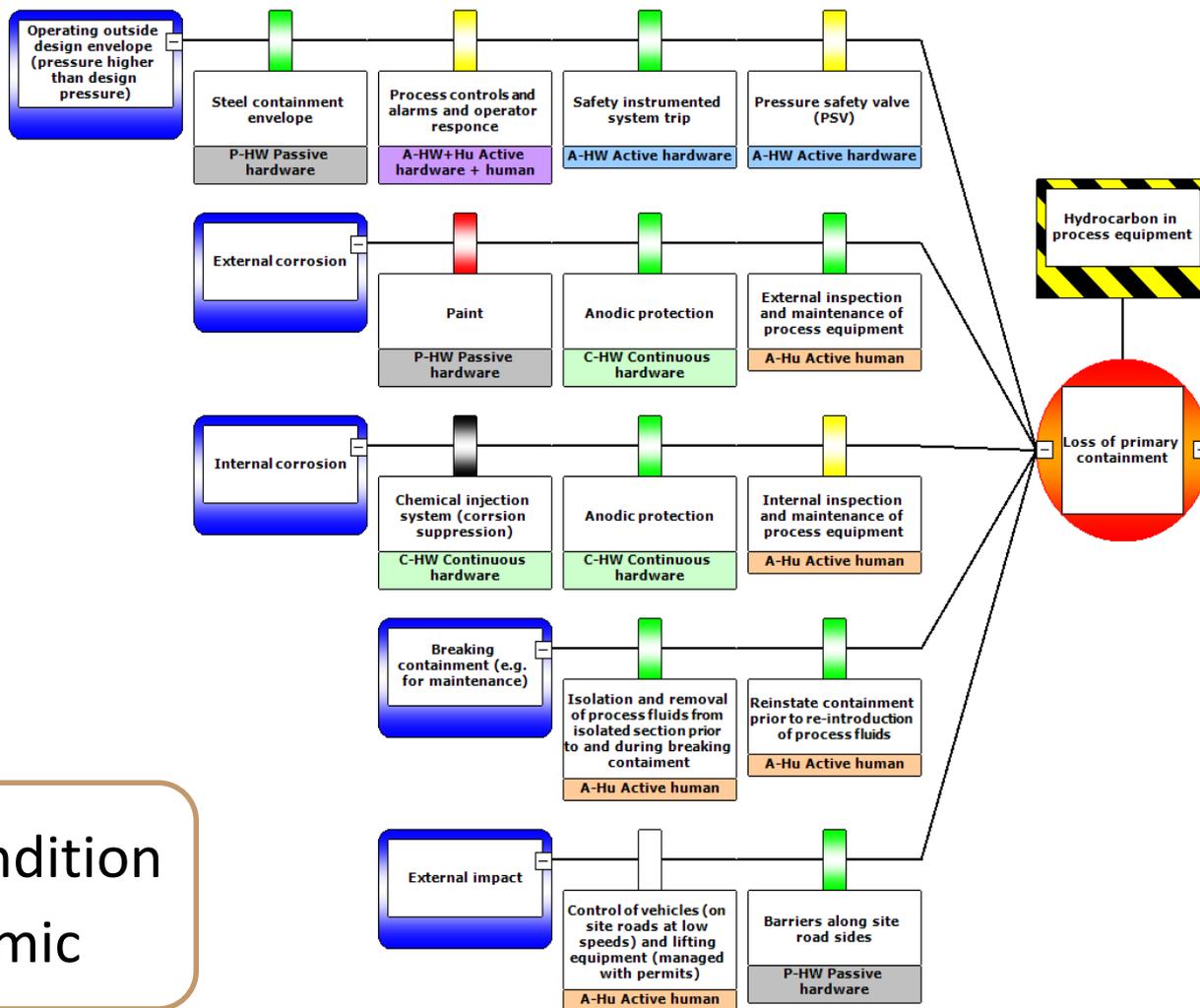


Barrier Condition and Scoring (EXAMPLE)

Condition (simple)	Condition (detailed)	Color code
Effective	In place, available and effective	Green
Partially effective	In place and available, but operating below its intended functionality	Yellow
Not effective	Not in place, not available	Red
No data	No operational information is currently available	White
Deactivated	Not in place, turned-off, deactivated.	Black
Optional expansion of category 'Not Effective'	Can also be used to differentiate a local system from corporate standards.	



Barrier condition
 is dynamic



Barrier condition
 is dynamic

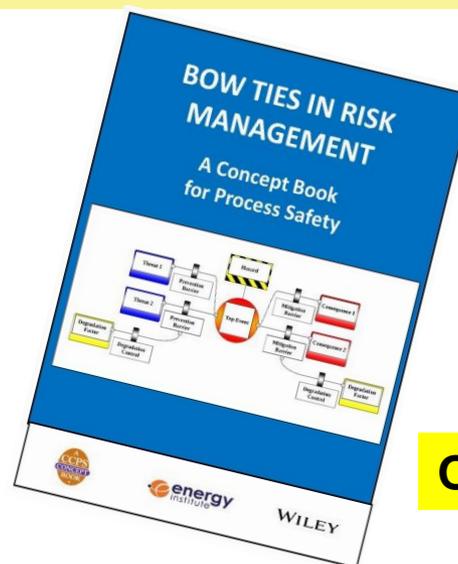
Five key questions when your barriers are degraded in an operational system

- 1. Consider the threats** - any changes in the context or demand under which the barriers operate (e.g. new threats; changes to throughput or environment)?
- 2. What is the current barrier condition?**
 - Are all the existing barriers functioning as intended?
 - What is status of the barriers, against the design intent or performance standard?
 - Are any barriers unavailable or deactivated on a temporary or long-term basis?
- 3. Can we continue operation, or do we need to shut down?**
- 4. Are immediate measures required** to strengthen barriers or add temporary additional barriers to allow continued operation?
- 5. How are the longer-term actions being prioritized** in order to restore barrier condition back to the design intent, or to meet the performance standard?

Well constructed bow ties make it very clear how risks are managed and major incidents avoided, and are increasingly used in high hazard industries.

This book reviews the bow tie method and explains how to construct highly effective bow ties and avoid common pitfalls, with sound and practical treatment of human and organizational factors

*It should be **on the desk of all managers and engineers** involved in operating hazardous facilities and in projects to build or change them...*



On sale Q3 2018

- **Barriers must be effective, independent and auditable**
... and encapsulate 'Detect – Decide – Act'
- **Clear distinction between barriers and degradation controls**
- **'Human error' treated as a degradation mechanism, not a main pathway threat**
- **Multi-level bow ties show more clearly how barriers can degrade and the role of the management system and leadership in controlling degradation**
- **Bow ties make active barrier management clear and obvious**

On sale Q3 2018

