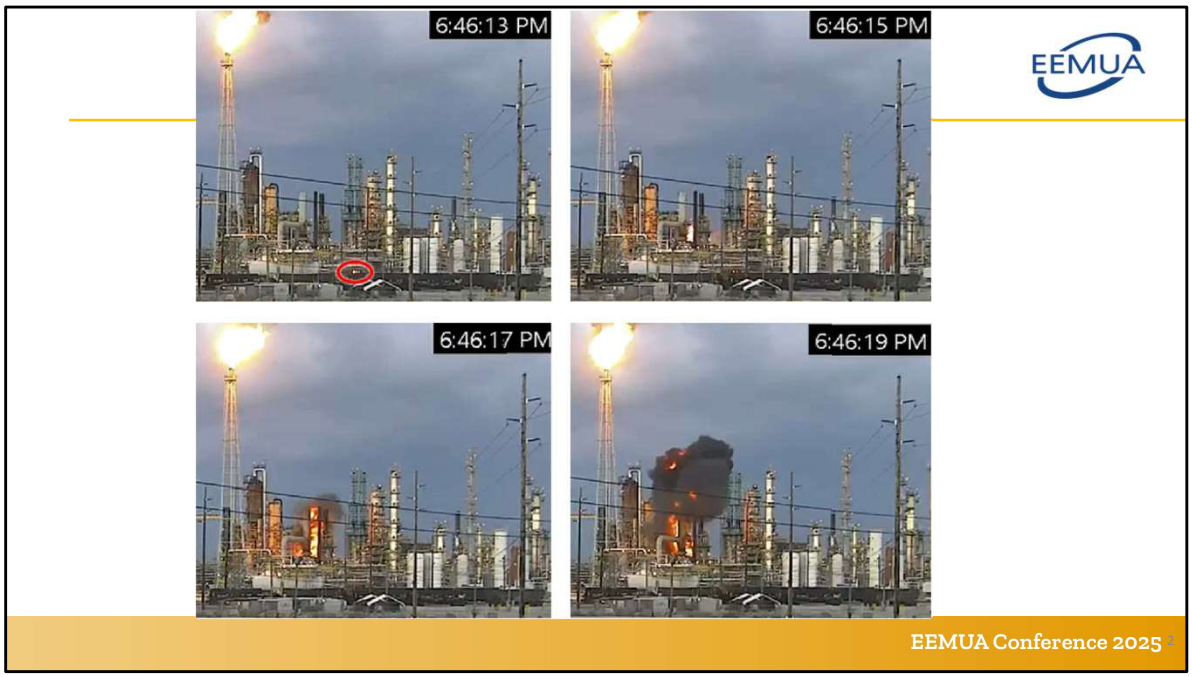
Chemical engineer with over 30 years in human factors. Last 20 as a freelance consultant.
Lead author of latest editions of EEMUA 191 alarm management and EEMUA 201 control room design



BP-Husky Toledo Refinery. 20th September 2022
Brothers Ben and Max Morrisey
According to the CSB report
Relied on human intervention to respond to process upsets and deviations. However, did not provide procedures, written instructions, or documented corrective actions for operators to respond to or troubleshoot the hazardous scenarios identified in safety studies.

Boeing 737 Max-8 two accidents with 346 fatalities – Ethiopian and Indonesian Lion Air lines

Physical size of engines increased. Moved further forward on the wing so that they can be raised

Weight and thrust affecting the aircraft natural pitch

Aircraft inherently unstable

Technology used to correct but it was unreliable and pilots were not told how to recognise problems or how to respond

Conventional 'wisdom'

Engineering is reliable – Humans are unreliable

EEMUA Conference 2025

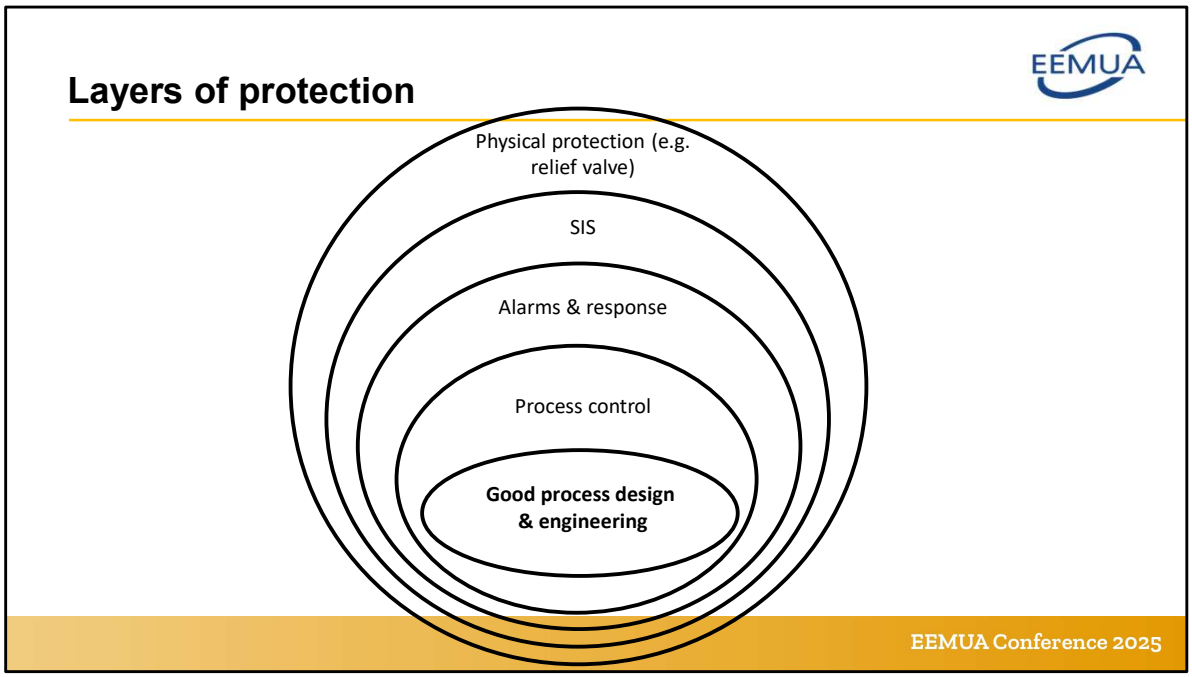
Our industries are dominated by engineers. Commonly held view is that humans are the problem so we need to replace them with technology wherever possible

The explanation is that people make mistakes and so are unreliable.

Seems unfair because human reliability is being measured using metrics suitable for machines. It is totally correct that people do not always respond situations in the same way whereas the output from a machine is quite easy to predict.

It would be easy to blame people for the two accidents mentioned, which Boeing did, but a closer look shows how it was the engineering that was the main failure.

This is clearly an AI generated image. Although very powerful AI is raising concerns about how it can be trusted. The sensible view is that AI will not replace people but people using AI will replace people who do not.



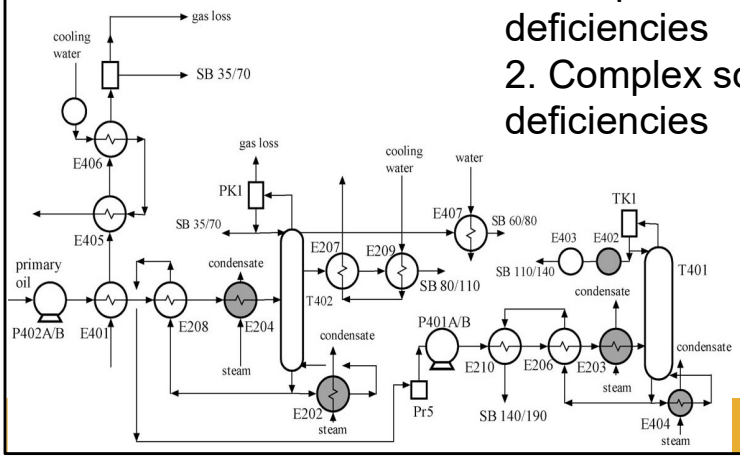
The introduction of more sophisticated automatic control and Safety Instrumented Systems (SIS) seems to lead us to safer systems. But event this traditional representation of layers of protection shows that there is a critical role for the human to accept and respond to alarms. Why would we do that if humans are so unreliable? The answer is that we have created systems that don't want to run. We need people to stop the SIS activating.

This model is fine as long as we consider the quality of the layers not assume that more layers is good. One of the problems is that adding more technology increases complexity.

Also, this approach leads to less emphasis on inherent safety.

There are two types of design

1. Simple so there are obviously no deficiencies
2. Complex so there are no obvious deficiencies



Trevor Kletz godfather of process safety. More complex system, more opportunities for equipment failure and human error. Computer scientist Tony Hoare 1980s. If something is simple you can see what is wrong. Complexity is a very good way of hiding problems.

Process flow diagram - number of exchangers allow good heat integration means but any minor change affects a wide part of the plant. Good reasons for doing this but have to recognise risks.

More layers of protection makes it difficult to keep them independent so difficult to predict how they work in practice and risk reduction achieved – may actually increase risk especially when human perception is included.

Paul Fitts – 1950's

People are better than machines at:

Detection	Perception	Judgement
Induction	Improvisation	Long term memory

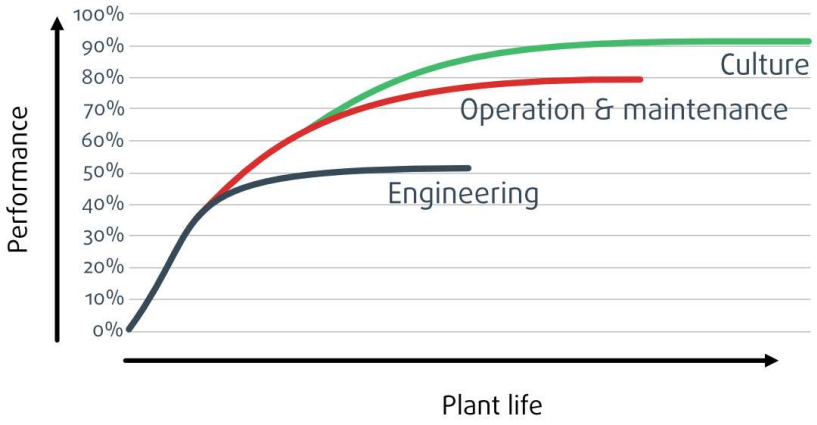
Machines are better than people at:

Speed	Power	Computation
Replication	Simultaneous operation	Short term memory

Paul Fitts pointed 1951 pointed out that people and machines have different strengths and weaknesses.
Our systems will work better if we design with these in mind.
Not current approach of automating everything that is easy to automate.
Does this stand up in 2025? Technology has increased the data available but people are still better at making sense of it.

Human factors

- Softer issues
  - Culture
  - Leadership
  - Teamwork
  - Competence
- Harder issues
  - Interfaces
  - Physical ergonomic
  - Procedures
  - Working environment

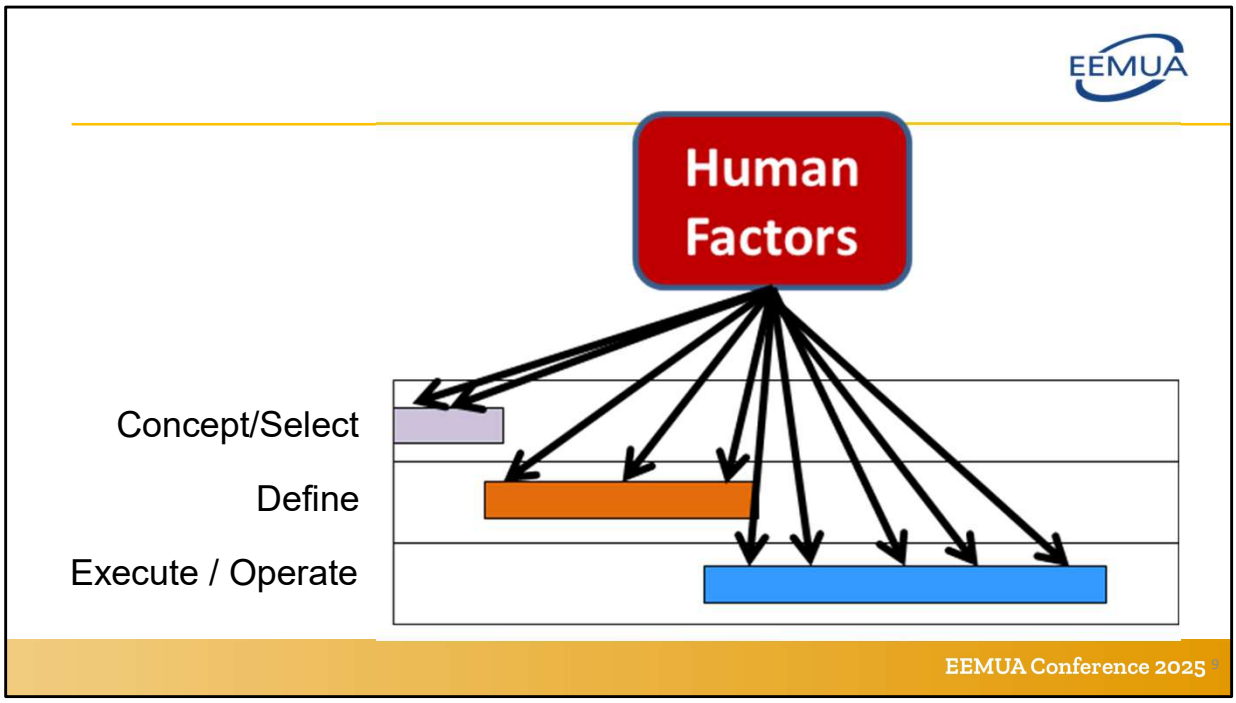


Human factors is a scientific discipline concerned with the understanding interactions between humans and other elements of a system.

It is very wide ranging. Some of it is in softer areas like culture and leadership. These are very important but will only be effective for well engineered and managed systems

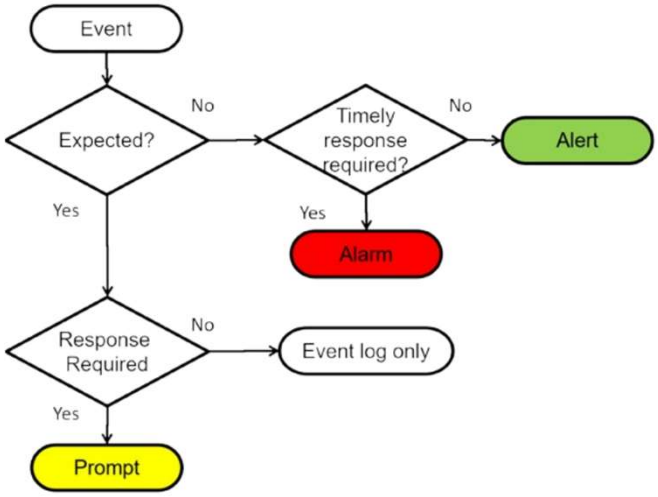
Ironically the harder issues are the easier ones for engineers to understand and influence. But we often miss the opportunities.

The chart has no real data but emphasises the importance of addressing all aspects of system performance including human early on. This is not to say culture should be ignored because unlike engineering it has not cost so the benefit comes for free.

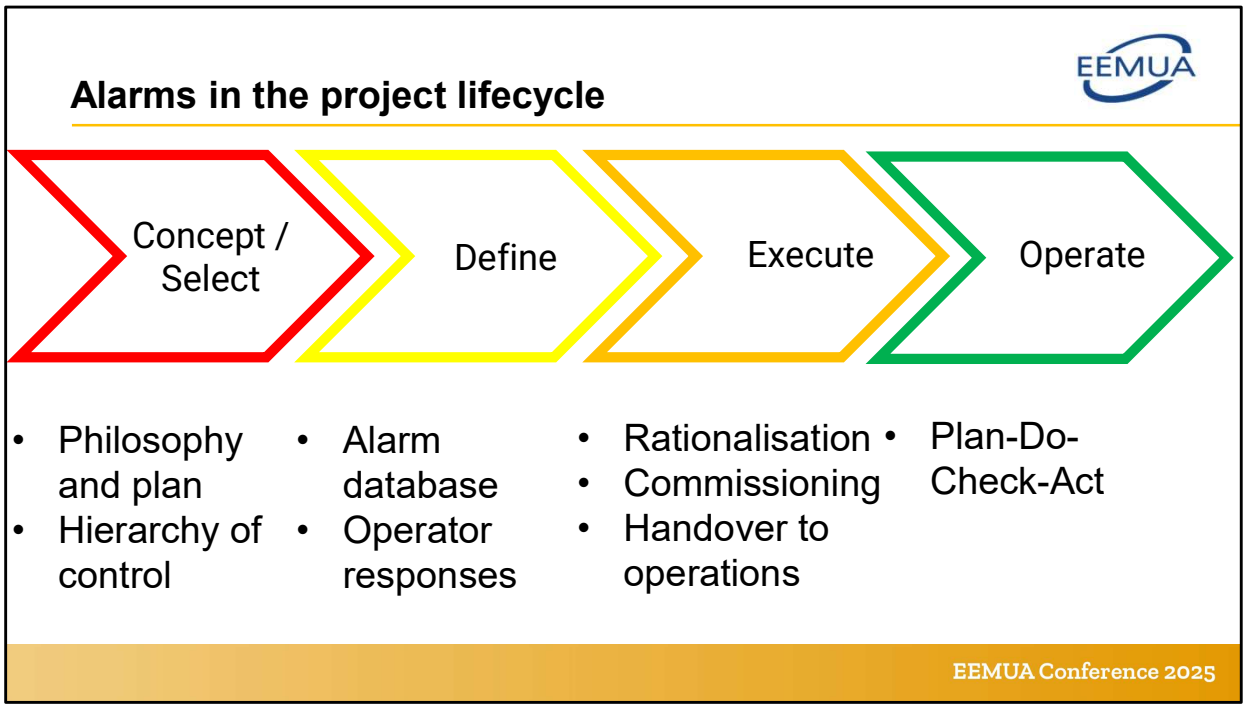


One of my key messages today is that for systems to function effectively we need to understand and support the human role throughout the system lifecycle.
Talking about human factors at the concept / select phases can ensure correct decisions are made.
All to often HF is left until too late. In new project it may not start until the O&M procedures have been written – which is usually just before or during commissioning.
Another key message is that it is not a one off activity but continues until decommissioning.

Alarm management



Looking at some specific examples. Alarm management is one area where we have created a mess.
Unnecessary and nuisance alarms, and floods of alarms when things go wrong. Not supporting the operator.
Default has been to provide alarms for every deviation.
EEMUA 191 gives a definition and process to make sure this does not happen. Alerts and prompts can be used as alternatives.



Illustrates how alarm management can and should be implemented.

Define the philosophy as soon as possible. Make sure alarms are considered within the hierarchy of risk controls.

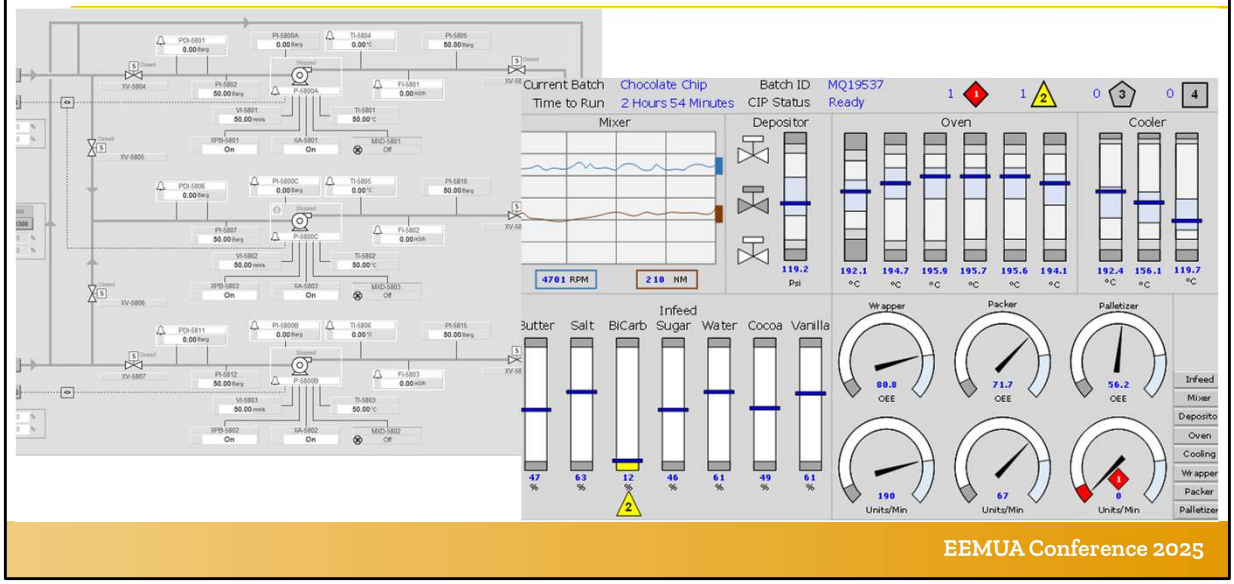
Alarm system design should develop as details of the system design become available.

Plan for formal rationalisation before handover.

And this continues as part of the plan do check act.

This approach can apply to most human factors issues.

Interfaces



Being encouraged to move from example on left to one on right.

Instead of recreating the system drawing, creating something that is aligned with human strengths.

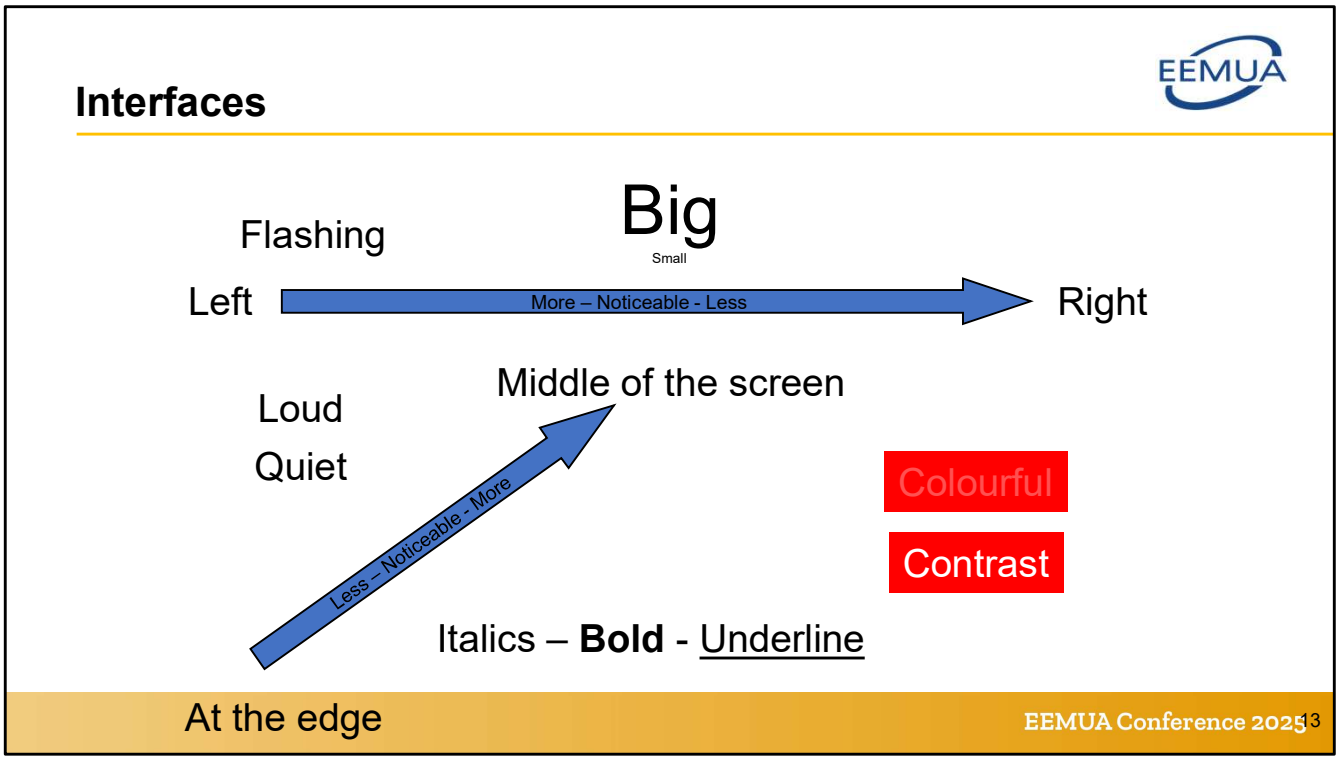
The example from ISA 101. Note the mixture of display types.

Minimal use of text. Not reliant on colour – text and shape provided as well

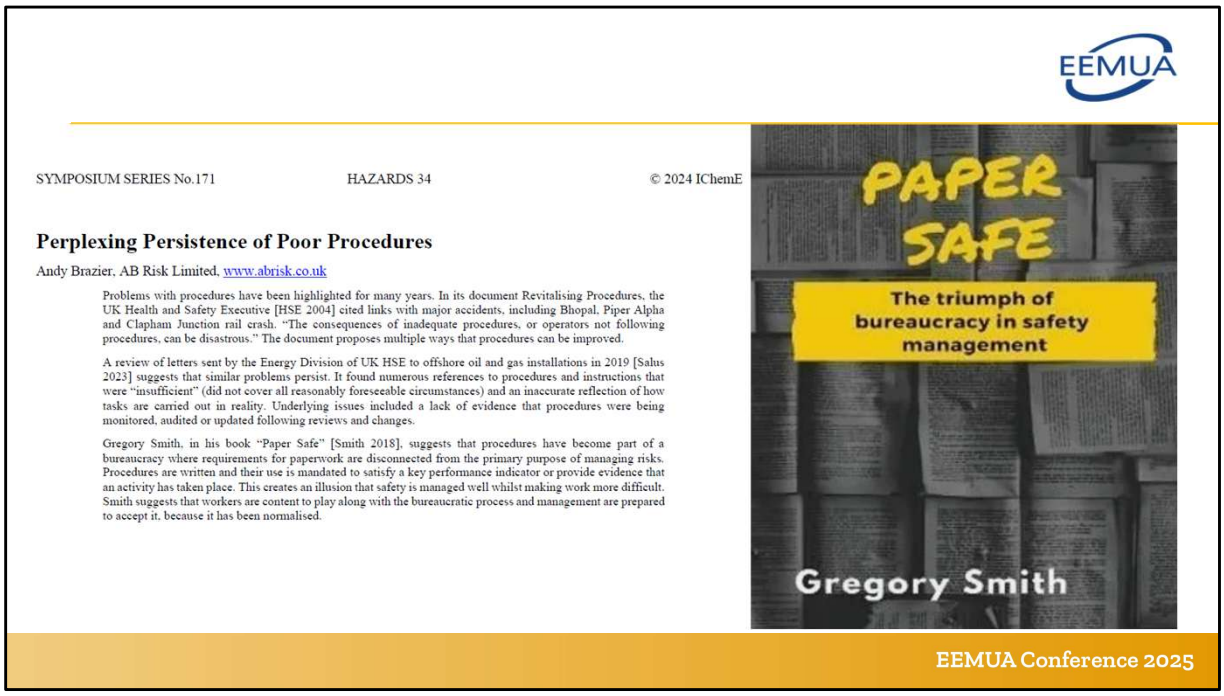
'At a glance' picture of the current state - 5 second glance

Early indication of problems

This is explained in EEMUA 201 3rd edition from 2019.



One way of explaining this is the way we view a screen.
It is clear that the most important information should be in the middle of the screen, followed by the left hand side.
Size, colour, contrast and font can all make a difference.
Flashing can attract attention but quickly becomes distracting.
If this is presented at the early stage of a project we are more likely to get interfaces that support the operator.



Procedures is another area where we can do much better. Despite a wealth of guidance most are still poor. I presented at last year's Hazards conference on this and am currently writing a book on the subject for the Center for Chemical Process Safety

An Australian lawyer Gregory Smith has captured issues in his book Paper Safe.

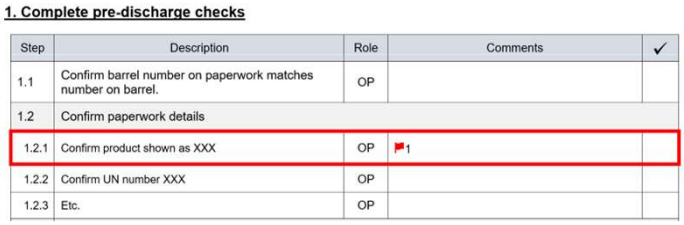
He observes that paperwork is largely disconnected from the primary purpose of managing risks

Use of procedures is often mandated to satisfy a KPI

Overall this gives and illusion of safety that workers and management accept because it has been normalised and there is significant resistance to change

Procedure Solutions

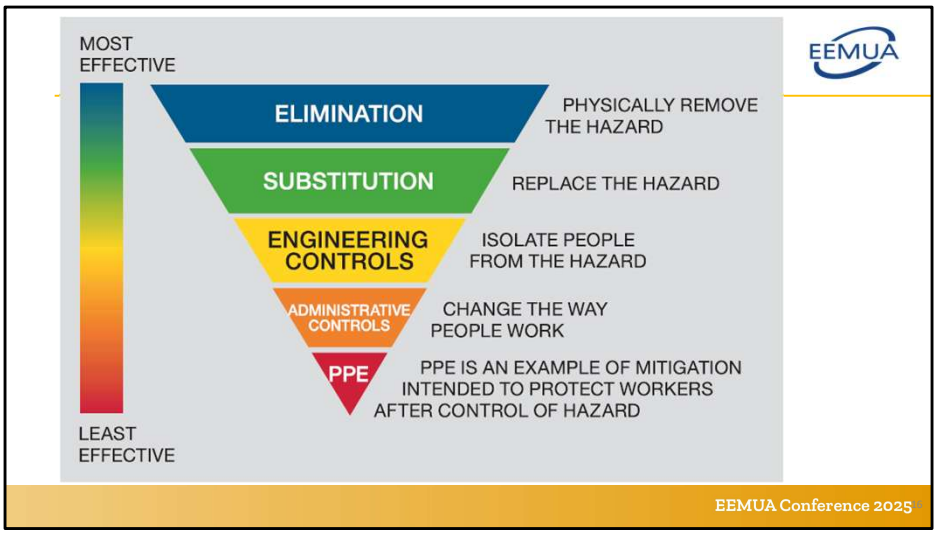
- Write to support competent people
- Specify how procedures should be used
- Specify what to do if they can't be used
- Limit the pre-amble
- Use a clear structure
- Be ruthless with wording



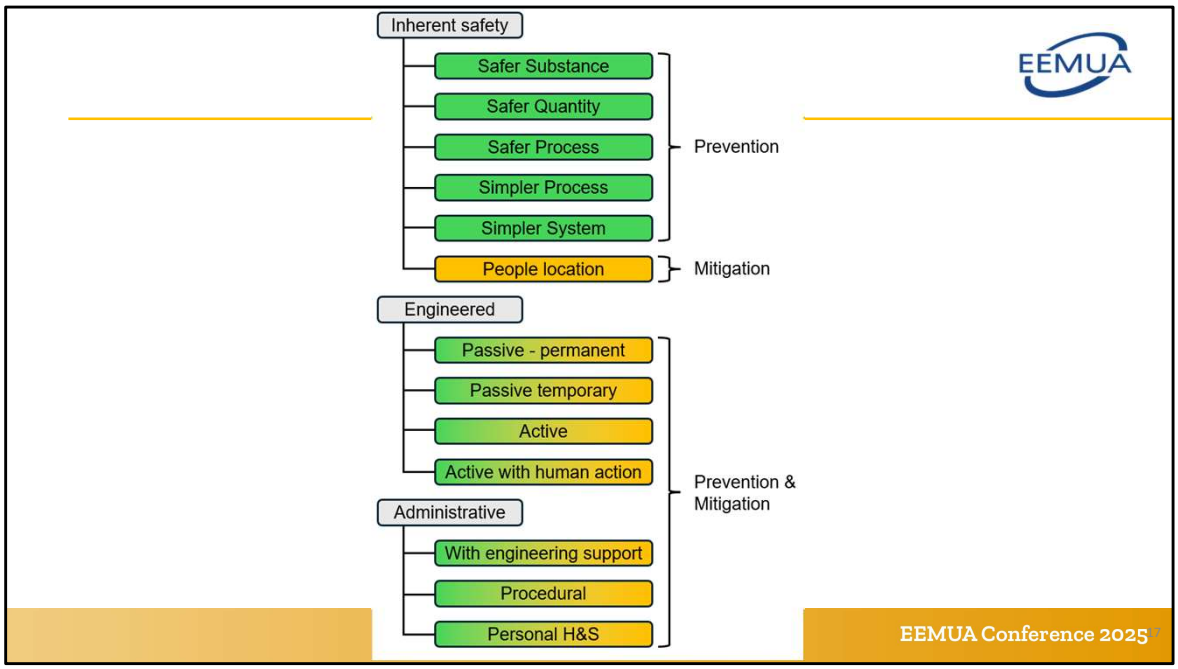
1. Complete pre-discharge checks

Step	Description	Role	Comments	✓
1.1	Confirm barrel number on paperwork matches number on barrel.	OP		
1.2	Confirm paperwork details			
1.2.1	Confirm product shown as XXX	OP	1	
1.2.2	Confirm UN number XXX	OP		
1.2.3	Etc.	OP		

Based on my recent work I have come to the following conclusions.
Procedures should aim to support competent people at work. Including other information, including training, detracts.
We need to specify how we expect each procedure to be used. Some will be print follow sign every time a task is performed. For others this is not appropriate.
No procedure is perfect and we need to advise about what to do.
A lot guidance suggests lengthy preamble. No one reads it.
Structure helps understanding. A long list of steps does not.
Overall we need to be ruthless with wording.



I think it is time to challenge the standard hierarchy of risk controls.
It is a great idea but doesn't work as a tool.
Also, it perpetuates the idea of engineering being better than human
Although it should always be our first consideration, inherent safety is not always an option and it may not always lead to the lowest overall risk. Avoiding manufacturing a material because it requires a hazardous process, and just buying it in has only moved the problem to somewhere else.



I wonder if expanding the hierarchy of risk controls could transform it from a neat idea to a useful tool. The current categories are very broad and the handling of mitigation is not very helpful/

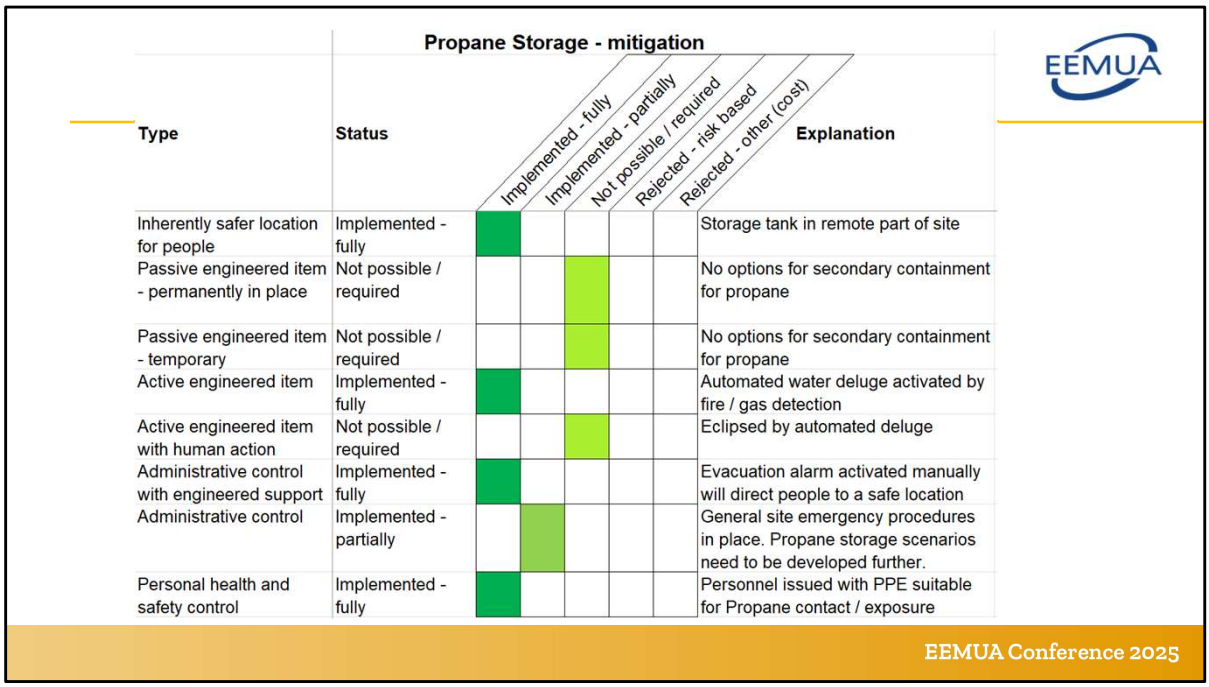
These are headings and I have been able to list examples under each, and I am comfortable that at all levels the hierarchy stacks up fairly well.

The colour code here is that green is a prevention control and orange mitigation. I concluded that there are engineered and administrative controls for both. However, the top five inherent safety controls related to substance and simplicity are preventative and the sixth related to people location is mitigation.

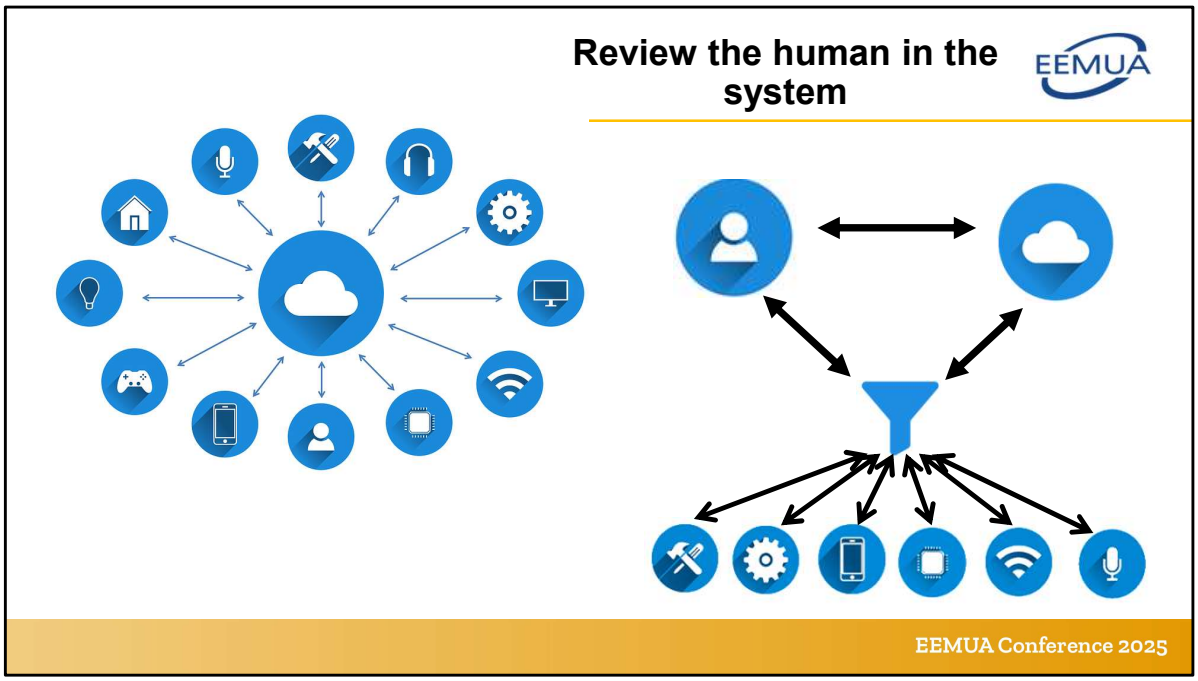
Propane Storage - prevention

Type	Status	Implemented - fully	Implemented - partially	Not possible / required	Rejected - risk based	Rejected - other (cost)	Explanation
Inherently safer substance	Rejected - other (cost)						Diesel could be used as fuel on site but cost is greater. Propane has better environmental performance.
Inherently safer quantity	Rejected - risk based						Smaller storage vessel would require more frequent deliveries.
Inherently safer process	Not possible / required						Storage conditions dictated by the substance.
Inherently simpler process	Not possible / required						Storage conditions dictated by the substance.
Inherently simpler system	Implemented - fully						Design philosophy to minimise reliance on add-on safety systems
Passive engineered item - permanent	Implemented - fully						Vessel and components fully rated for full pressure / temperature range
Passive engineered item - temporary	Not possible / required						Eclipsed by permanent arrangements

We could use it to evaluate the proposed strategy looking for balance instead of absolutes.



If we look at the mitigation controls the profile here seems to be well balanced and no options rejected. I have identified under administrative controls that there may be further work to do with emergency procedures for specific propane storage scenario.



It is time to recognise the strengths of humans rather than just focus on weaknesses.
The traditional engineering view on the left sees the human as one component of many.
Moving to the image on the right highlights how actively involving people in doing what they are good at, and assigning other tasks to the cloud.
A process to hand over and take back allows it to respond to all circumstances.

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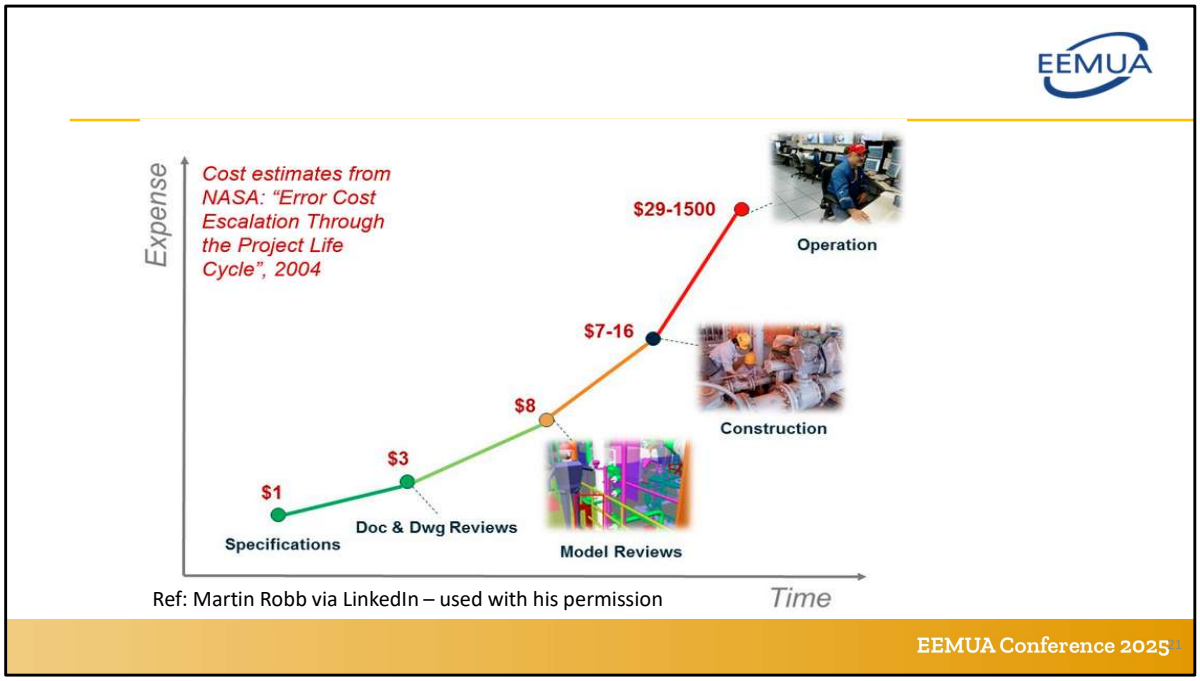

And I would like to close with this graph from Martin Robb. It shows how the sooner we consider the issues the cheaper and easier they are to solve.

- If you would like any more information you can contact me as follows:
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  - Phone – +44 7984 284642

I hope you have found this useful and thank you for your interest.
If you have any questions do not hesitate to contact me.


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