# Human Factors
# in
# Major Accident Hazard Industries

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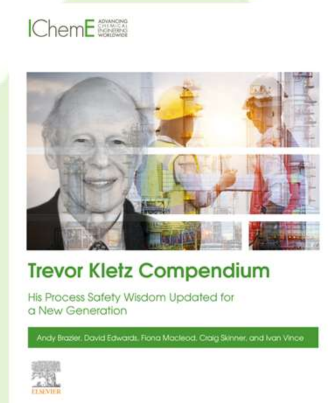
## A bit about me

- Chemical engineer
  - BSc - Loughborough University
  - PhD - Edinburgh University
- 28 years working as human factors consultant
  - 18 years self-employed
- Chartered member of the Chartered Institute of Ergonomics and Human Factors (CIEHF)
- Associate member of Institute of Chemical Engineers (IChemE)

# Experience

- Predominantly oil, gas, chemical, power and steel industries
- Human factors in major accident hazard (MAH) safety
  - Design assessments
  - Safety critical task analysis
  - Control room evaluations
  - Staffing arrangements
- Clients include Shell, BP, SSE, Centrica, Tata, Syngenta, Total, Maersk, Ineos, Perenco etc.

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# Places I have works – UK & Ireland


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# Places I have worked – further afield


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# Projects I have worked on but not visited


Limited

# Plan for this afternoon

- Human factors and major accident hazards
- Control room Human Machine Interfaces (HMI)
  - General requirements
  - HMI hardware
  - Graphical User Interfaces (GUI)
  - Alarm management
- Opportunities for you to discuss.

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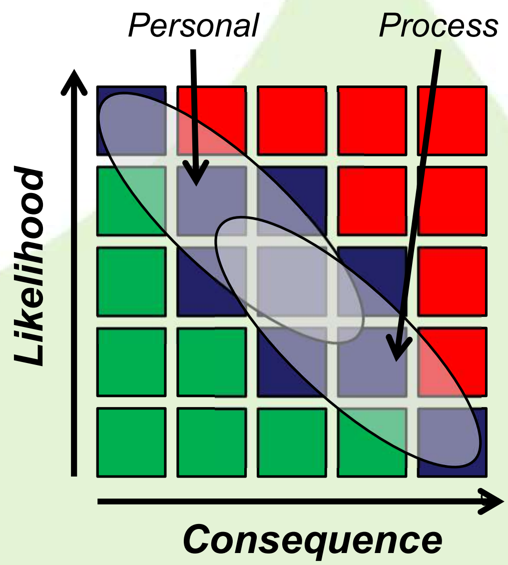
## Safety in MAH

- Handle very large quantities of hazardous material
- Challenging locations
- Process vs personal safety

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## Human factors and safety

- Up to 80% of accident causes can be attributed to human failures
- All major accidents involve a number of human failures
- Human factors is concerned with
  - Understanding the causes of human failures
  - Preventing human failures
- An important part of managing ‘major accident safety’

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**Deepwater Horizon Explosions & Fire**

***Why?***

1. *Annulus cement barrier did not isolate hydrocarbons*
2. *Shoe track barriers did not isolate hydrocarbons*
3. *Negative-pressure test accepted - integrity not established*
4. *Influx not recognised until hydrocarbons were in riser*
5. *Well control response actions failed*
6. *Diversion of mud resulted in gas venting to rig*
7. *Fire and gas system did not prevent ignition*
8. *BOP emergency mode did not seal well*

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## BP Texas City



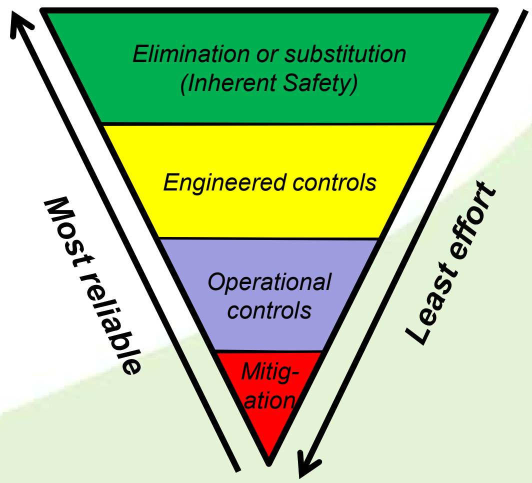


## Video – BP Texas City

**Group activity**

**Identify human factors that contributed to the accident**

## Managing risk - hierarchy of control

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**Risk profile** — *Prioritise according to risk of MAH*
*QRA, HAZID*

**Hazard detail** — *Identify deviations leading to MAH*
*HAZOP, PHR*

Barriers/controls

**Engineered**

**Human**

**Hierarchy**

1. *Inherent safety*
2. *Passive engineering*
3. *Active engineering*
4. *Alarms with human response*

**Task or activity?**

**Task analysis**

1. *Human Machine Interfaces*
2. *Alarm response*
3. *Emergency response*
4. *Generic competence*
5. *One-off risk assessment*
6. *Allocation of function*

*Bowtie?*

**ALARP**

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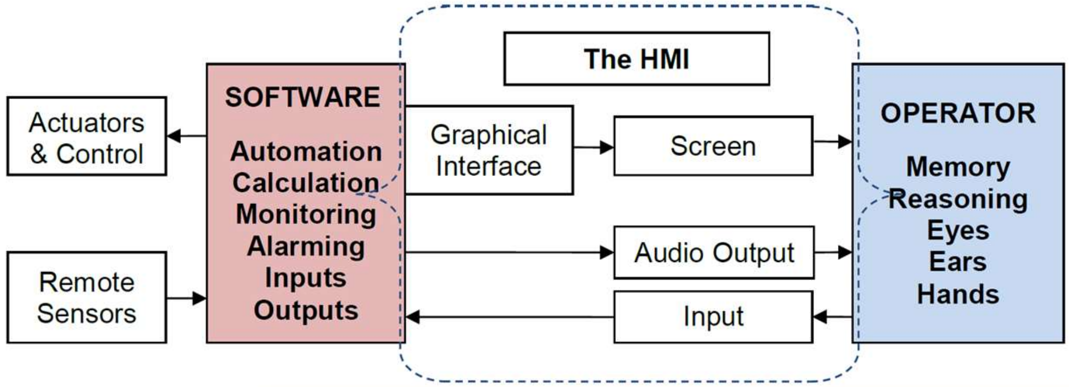
## Human Machine Interfaces




- Hardware and software

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## General requirements

- Support competent operators to perform their job safely and efficiently
- Provide operators with the information they need
  - Not just the data that is available
  - Exclude unnecessary information
- Take account of strengths and weaknesses

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## Humans have limited capacity

- Physical and mental
- Excess workload results in
  - Slower performance
  - Increased likelihood of error
- Under-load results in
  - Boredom
  - Loss of situational awareness
  - Reduced alertness

Still on Human Version 1

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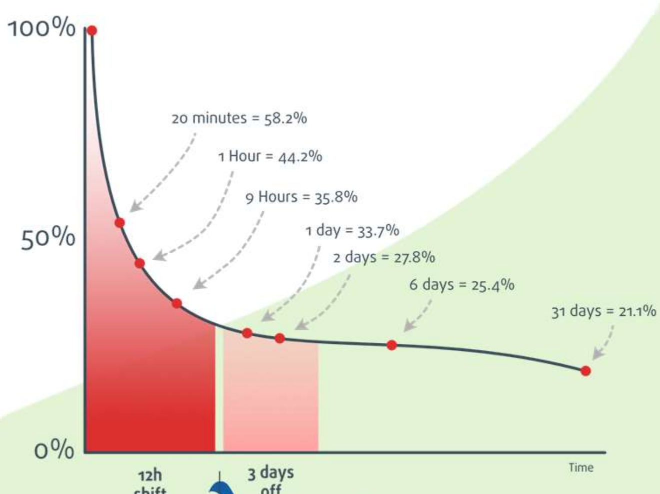
## Forgetting curve - Ebbinghaus

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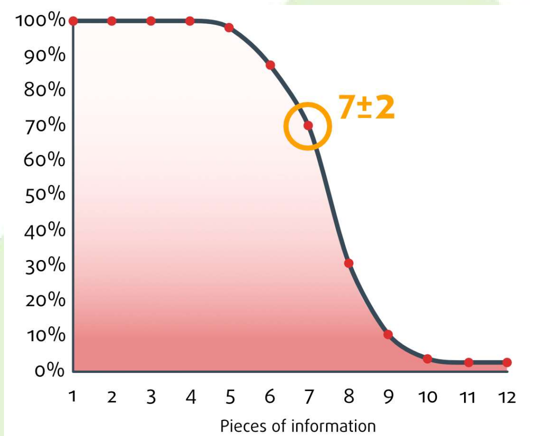
## Miller's law

- How many pieces of information can the human brain handle?
  - On a very good day it may be 9
  - When things are not so ….
- To deal with this people
  - Simplify
  - Assume
  - Estimate
  - Guess

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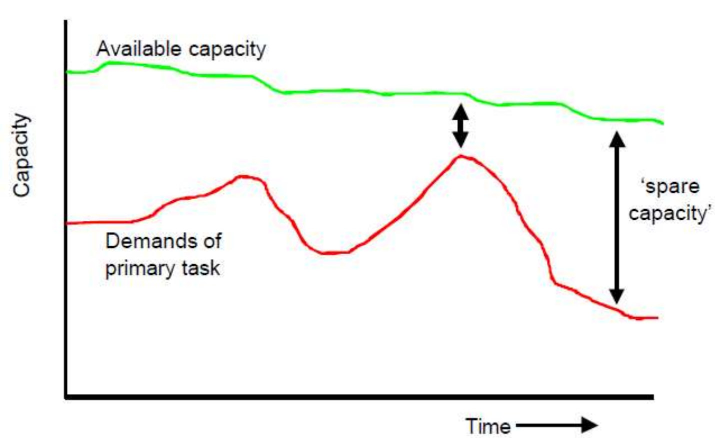
## Optimising workload

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## People vs technology

- In 1950's Paul Fitts developed a list for function allocation
- 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

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## Group activity

**Where do human capabilities exceed latest technology?**

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## Control room HMI evolution - original

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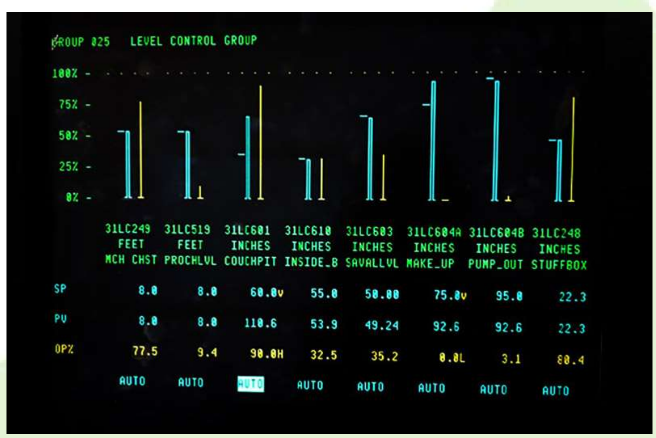
## Control room HMI evolution – early computers

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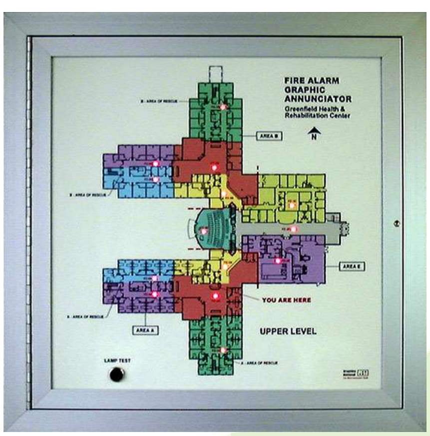
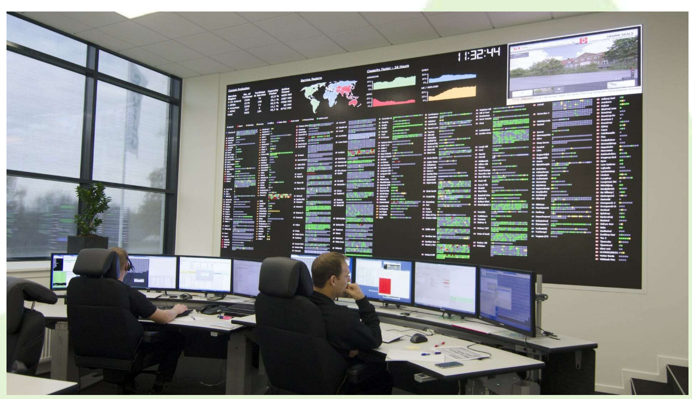
# Control room HMI evolution - modern



# Control room HMI evolution – additional items



## Group activity

**What were the benefits and disadvantages of older HMI?**

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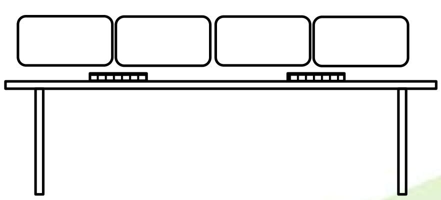
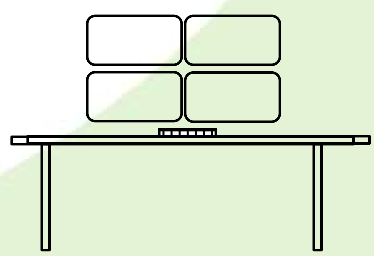
## How many screens can an operator use?



*vs*



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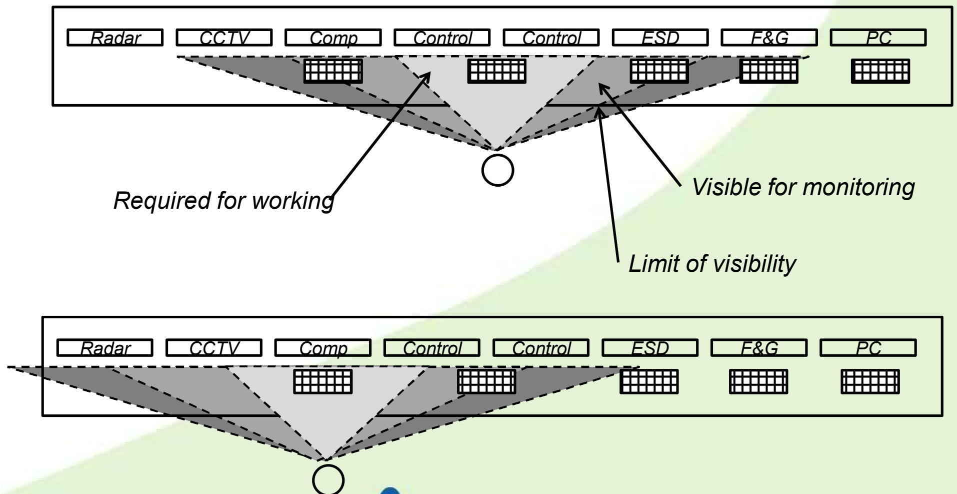
# Working vs monitoring

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# Factors to consider

- Other items on the desk
  - Input devices (how many?)
  - Office computer
  - Communications devices
  - Standalone interfaces
  - Paperwork
- Optimise data density vs no. screens - all modes of operation
  - Normal
  - Start-up / shutdown
  - Emergency
  - Operator training.

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## Graphical interfaces

- Situational awareness of
  - Current status
  - Recent past
  - Likely future
- Graphical elements
  - Current data
  - Data trends
  - Input screens
  - Navigation links
  - Alarms and alerts
- Design aims
  - Simple / intuitive to use
  - Consistent
  - Complete
  - Reliable
- Scenarios
  - Monitoring
  - Performing tasks
  - Responding
  - Learning.

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## Use of colour

- General aims
  - Minimise eye strain
  - Highlight critical information
  - Cultural norms
  - Nice to look at
  - Account for colour blindness
- Key requirements
  - Consistent
  - Unique meaning

White on black

Black on white

Black on grey
White on grey

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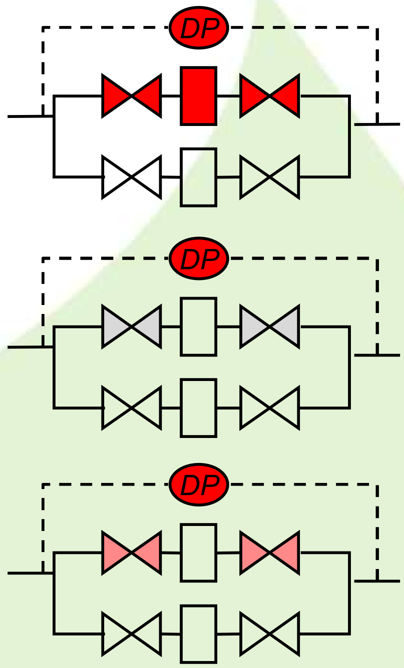
## Alarms and status

- Traditionally colourful displays
- Modern idea of shades of grey for status – operators dislike
  - General principles or change?
- Requirement for unique meaning
  - Doesn't have to be grey

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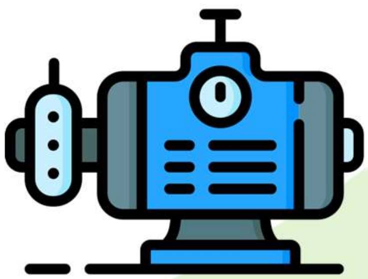
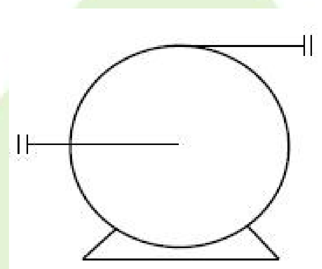
## Use of symbols





- Minimal but meaningful
- Consistent

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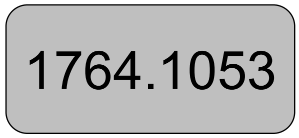
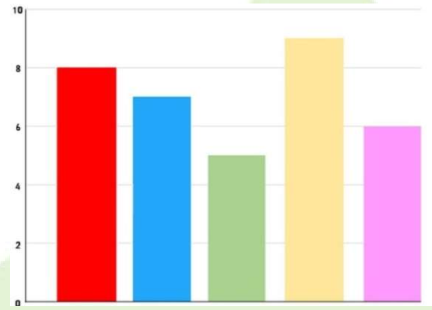
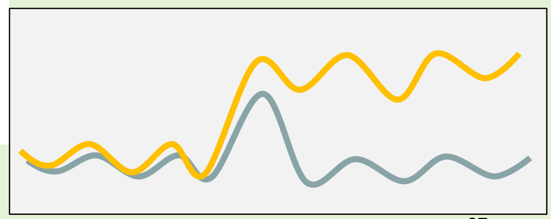
# Displaying data

- Numerical
- Bar charts
- Analogue dials
- Trend displays



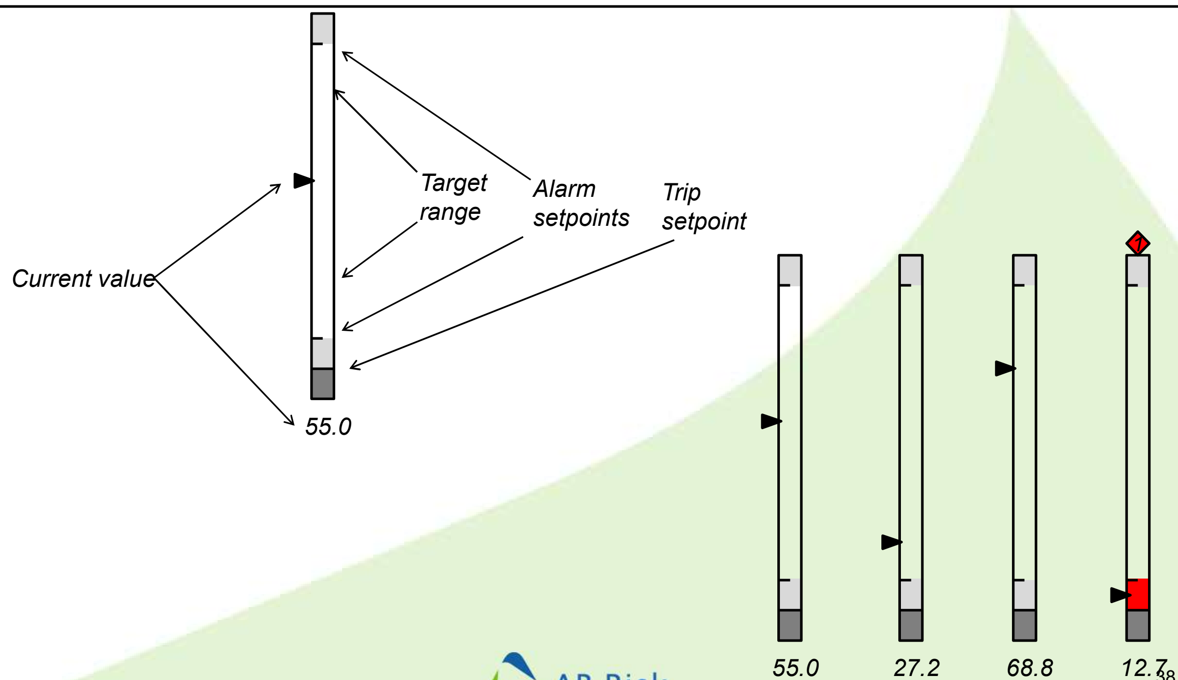










# Group activity

## Pros vs cons

**Numerical / bar chart / analogue / trend**

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## Interfaces

Flashing

Big

Small

Left More – Noticeable - Less Right

Loud

Quiet

Middle of the screen

Less – Noticeable - More

Colourful

Contrast

*Italics* – **Bold** - Underline

At the edge

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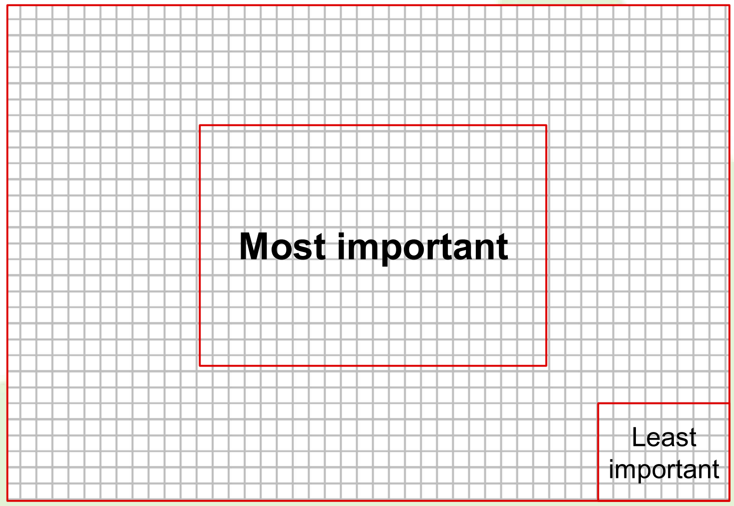
## General principles of graphics design

- Operator responsibility
- Priority vs complexity
- Assign size of areas on the page for each
- Location according to priority

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## Types of graphic display

- Level 1 – Overview
- Level 2 – Control
- Level 3 – Detailed
- Level 4 – Alarms and alerts

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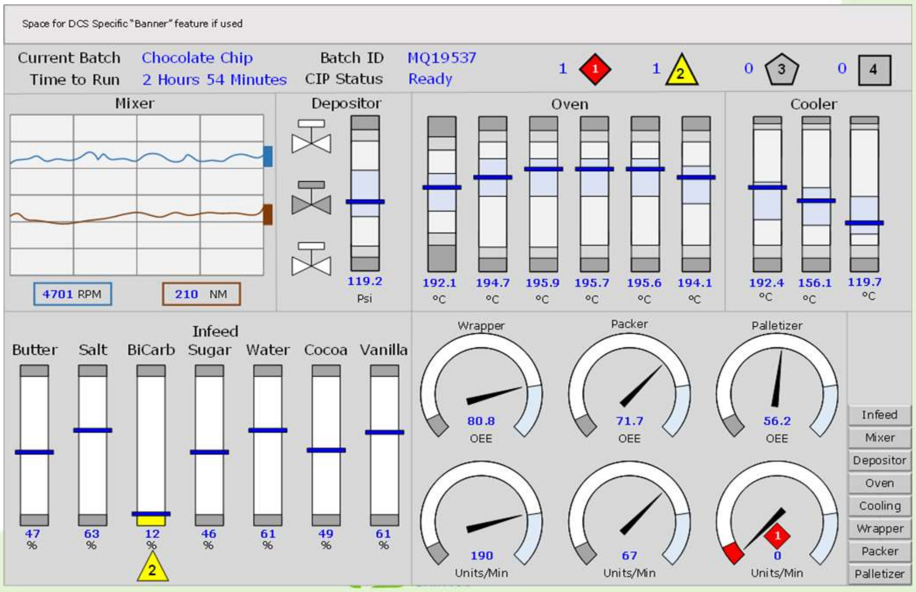
# Level 1 – Full extent of operator responsibility




*From ISA 101*

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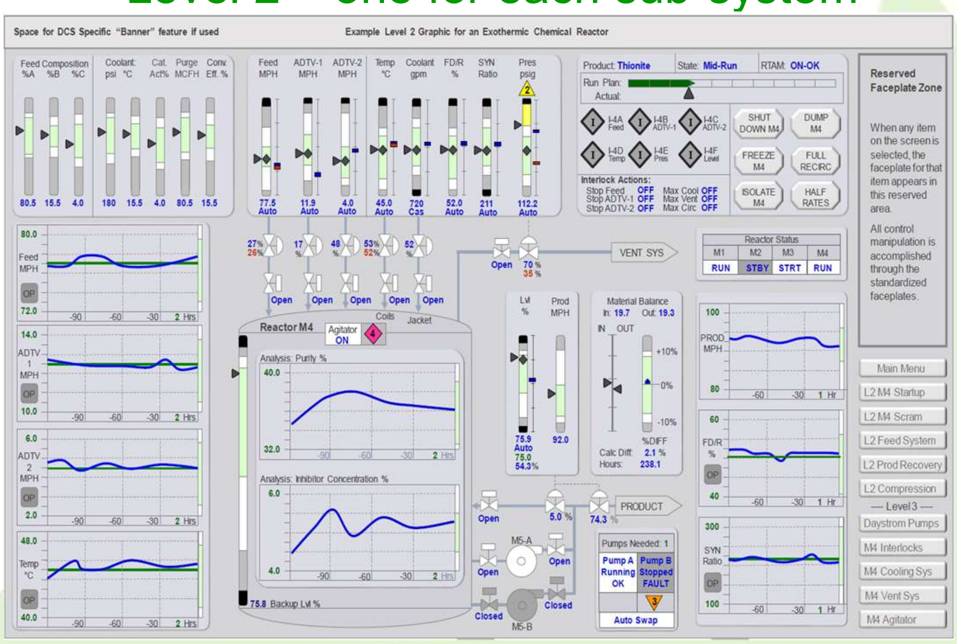
# Level 2 – one for each sub-system




*From ISA 101*

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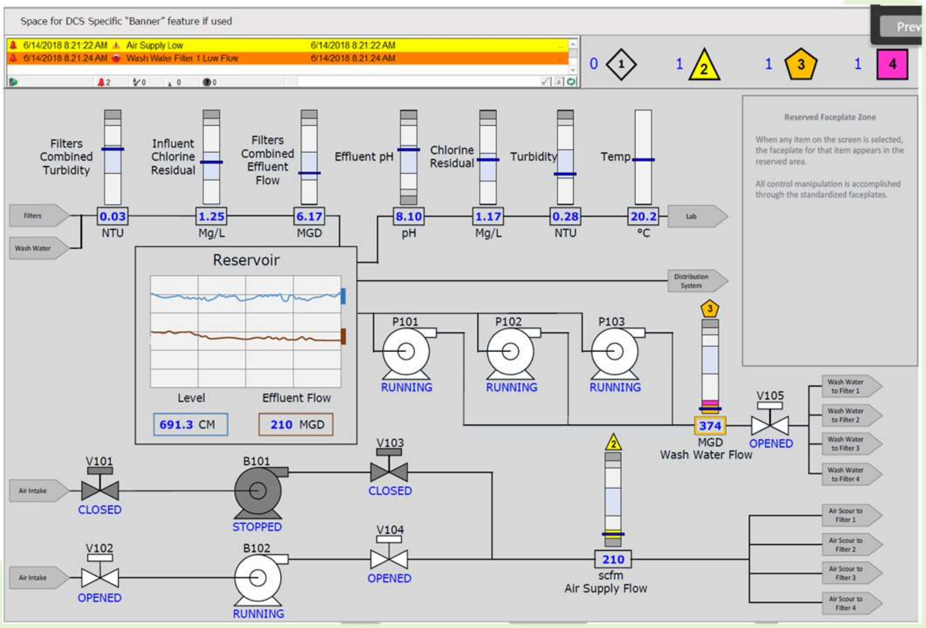
# Level 3 – specific equipment / task




From ISA 101

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# Alarms are our solution??

- Definition of alarm
  - An audible or visible means of indicating to the operator an equipment or process malfunction or abnormal condition
  - The purpose of an alarm system is to direct the operator's attention towards plant conditions requiring their timely assessment and action.
- No shortage of alarms
- But we still have incidents and accidents
  - Operators not aware of the what is happening
  - Do not recognise the seriousness.

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## Common problems with alarms

- Nuisance alarms during normal operation
- Floods of alarms during process upsets
- Poorly defined or described alarms
- Inconsistent prioritisation
- Response to alarms not defined
- Over-reliance on alarms – failure to adopt inherent safety or engineering controls
- Failing to take into account human strengths and limitations when choosing what to alarm.

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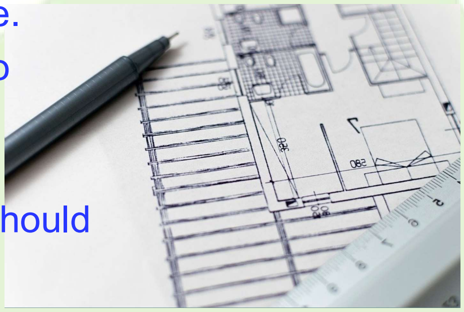
## Alarm design principles

- Each alarm should attract, inform and guide
- Every alarm presented to the operator should be useful and relevant to the operator
- Every alarm should have a defined response.
- Each alarm should allow the operator time to respond
- Nuisance alarms should be avoided
- Demand on automated protective systems should be minimised.



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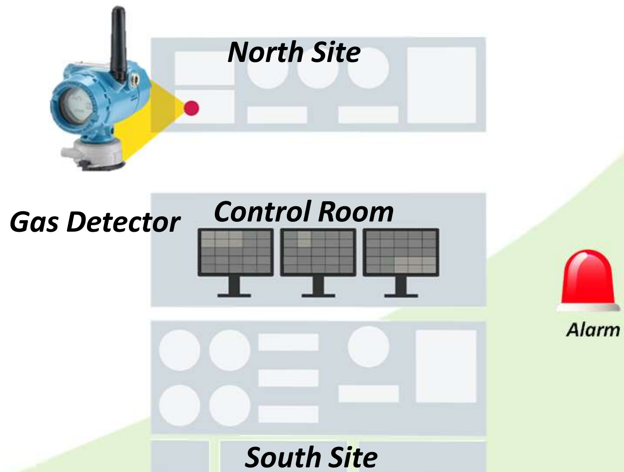
# Consider this scenario

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# Toxic Gas!!!
# How should the operator respond?

- Assume genuine and activate emergency response?
- Watch for other alarms – if none ignore it?
- Ask someone to drive to site to investigate?
- Assume it is a false alarm unless someone phones to report a leak?

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## More context

- Morning meeting - maintenance teams working at North site
- Control room operator is very busy
- Toxic gas detectors routinely require testing and maintenance, which sets off the alarms
- Control room operator has received lots of false toxic gas alarms - no genuine releases

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## How do you think the operator would really respond?

- Creating an alarm for every event is not an effective way of keeping operators informed.
- Present information to people so that they can detect potential problems early and only use alarms for the most serious situations.

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## Control room design

- Operators have key role in managing risks of modern process plant
  - Detect deviations early
  - Diagnosis and respond
  - Reduce reliance on automated systems
- A good quality interface ensures operators have the data they need in a useful format – situational awareness
- The working environment affects health and alertness
- Physical design and provision of equipment supports effective communication.

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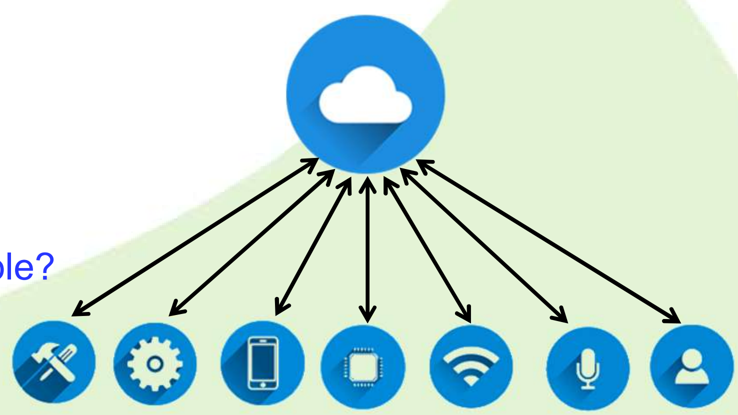
## Internet of Things (IoT)

- Technology developments
  - More components
  - More data
  - More connections
  - Less people
  - Faster change
- How do we handle people?



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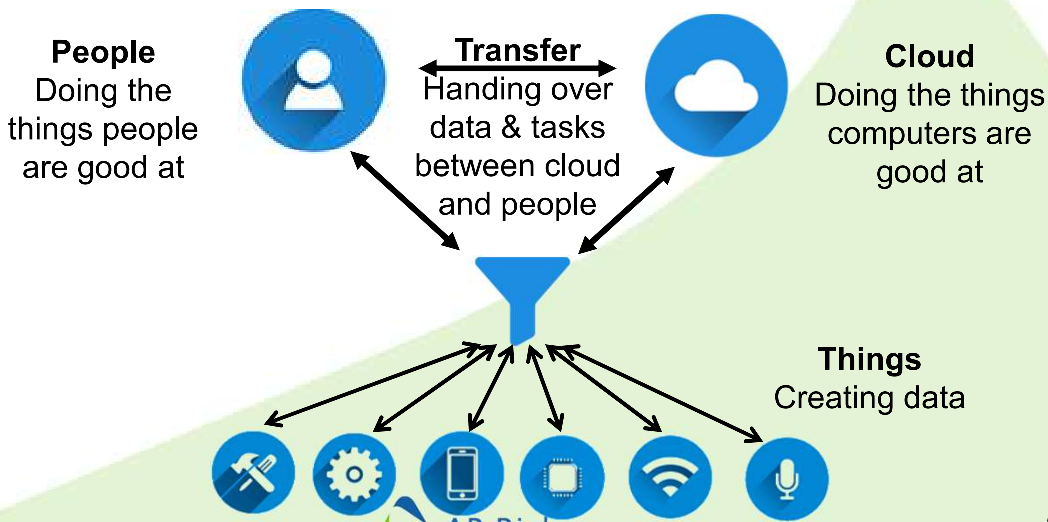
# Acknowledge the role of people

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# I hope you found that useful

- If you would like any more information you can contact me as follows:
  - Email – andy@abrisk.co.uk
  - Phone – +44 7984 284642

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# References

| Topic | Publication (bold = free) |
|---|---|
| BP Texas City video and reports | **https://www.csb.gov/bp-america-refinery-explosion/** |
| Human Factors Engineering | **https://publishing.energyinst.org/topics/human-and-organisational-factors/design-ergonomics,-control-design,-alarm-handling-etc./human-factors-engineering-in-projects** |
| Task Analysis | **https://abrisk.co.uk/task-analysis/**<br>**https://ergonomics.org.uk/resource/comah-guidance.html** |
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