TOTAL PETROCHEMICALS

Operator reliability

taking automation to the next level

Automation and Control for Energy
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Symptomatic 20st century joke in the world of Process Automation

- Question :

How many resources do you need to run a refinery ?

- Answer : *Two : one operator and one dog*

The operator is there to feed the dog

The dog is there to make sure

that the operator doesn't touch anything…

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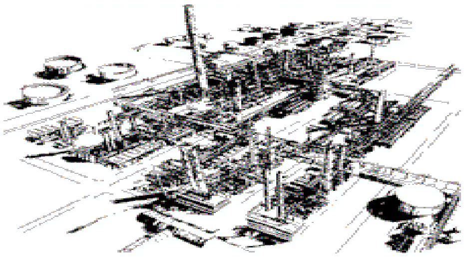
The 20st century
Automation Engineers' heaven :

100% automated plants
No more operators, no more human errors
Infinite workforce productivity

Just a matter of time and resources…



Just a matter of time and resources … ?

- **Major investment effort**
  - Digitalize all controls
  - Develop software applications and optimizers
  - 2003, voting systems, UPS, …
  - Fool-proof SIS, Layers of Protection, risk matrix …
  - …
- **In the meantime, human errors continued to happen with evolving diagnosis**
  - ~1970 : "Humans are not machines"
  - ~1980 : "residual problem from the past, will soon be solved"
  - ~1985 : "need more detailed procedures for remaining human interventions"
  - ~1990 : "problem to transfer competency to new generation operators"
  - ~1995 : "need behavioral program … so that procedures are followed"
  - …

21st century : several wake-up calls

Human Performance Error in operations and maintenance functions = still major risk contributor

Selection of reported accidents and near misses, 2007 - 2009

2007-065	2008-026	2008-028	2008-059	2008-061
Burns by caustic soda during operator intervention at a pump	Worker spread with sulphuric acid	Working on a blind while system still in service	Worker spread with sulphuric acid	Ethylene ship connected to propylene loading arm

2008-065	2008-070	2008-072	2009-014	2009-020
Isobutane cloud after rupure of nitrogen hose during startup	Large benzene spill in pipeway	Hot quench oil spread on operator after manometer removal	Large fuel oil spill after contractor opened purge	Fire during furnace startup

Classical (20st century) approach of Automation

Operator = (un)avoidable source
of errors and losses

- Human errors are at the origin of many incidents of process safety, reliability, …
- Automation objective = avoid depending on human intervention
- Technology = a tool to reduce the exposure of the process to human intervention and errors
- Operator error = caused by not following procedures and / or lack of competency

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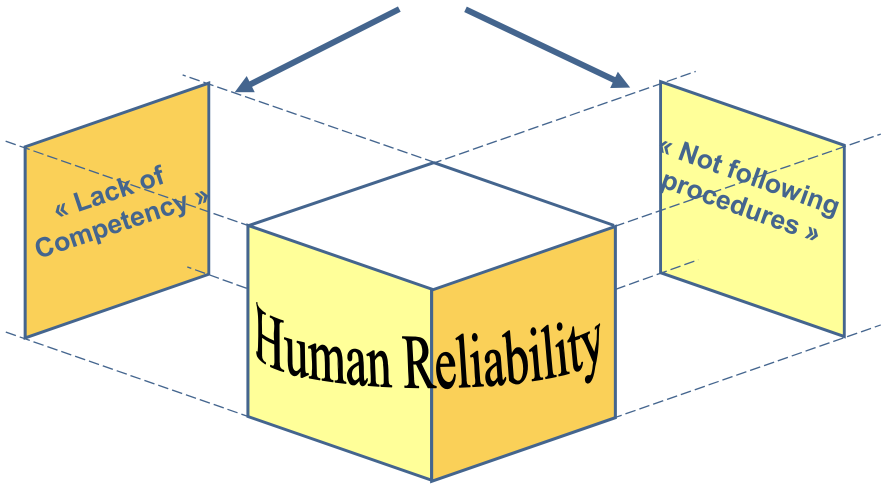
Human error :
2 most observed root causes



Just aspects of a more complex reality

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« Humans are not machines… »

… so we cannot do anything …

Let's do AT LEAST what we, engineers, do for machinery :

- ensure utilisation in their optimum operating range
- install alarming and overload protection
- ensure long lifetime with a maintenance plan
- design an adapted control scheme to influence their functioning
- use our expertise to constantly enhance their RELIABILITY

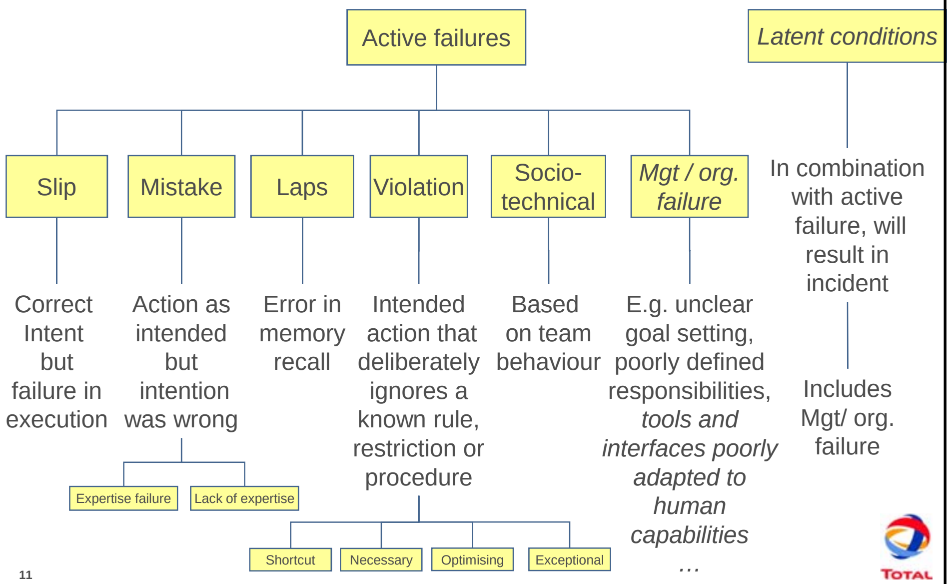
= the ('hard') science of
Human & Organisational **Factors**

Human & Organisational **Factors : domain**

- **Basis = brain functioning**
  - Handling of conflicting priorities
  - Tunnel effect
  - Types of memory
  - Mental modes of operation
  - …
- **Understanding of human error mechanisms and influencing factors**
- **<u>HARD</u> science : fully quantified**
- **<u>Applied</u> science : nuclear industry, aviation industry, military …**

Human Error typology in the Process Industry :

Classification according to CCPS



The human 'control loop' of the operator

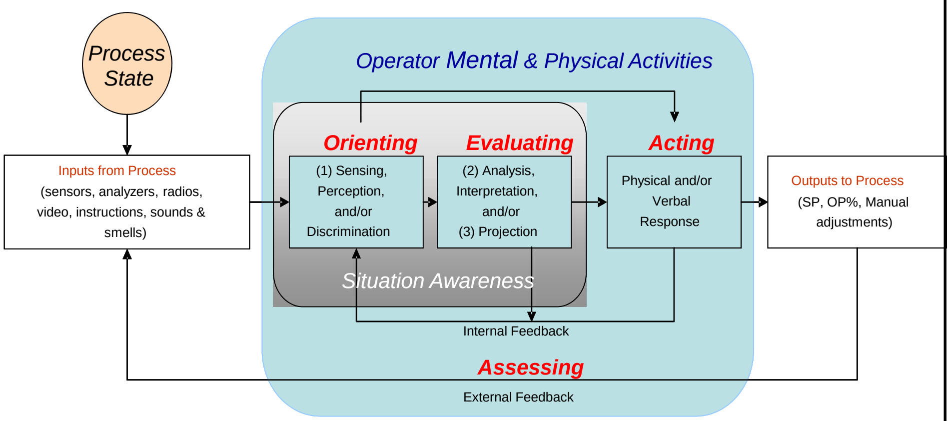


Figure from the ASM Consortium

Adaptation of Supervisory Control Activity models of Jens Rasmussen and David Woods - CMA.

Factors which influence the overall intervention success of the operator

Orienting
- Information overload
- Missing information
- Inappropriate level of detail
- Vigilance decrement
- Difficult navigation
- Distracting environment

Evaluating
- Inconsistent information
- Inaccurate information
- Conflicting priorities
- Lack of knowledge
- Inappropriate detail
- Poor information accessibility

Acting
- Inadequate communications
- Deficient / complex procedures
- Fail to follow procedures
- Inappropriate actions
- Inappropriate tools / interface
- Lack of experience
- Inadequate feedback

Assessing
- Lack "big picture" view
- Inaccurate information
- Inadequate information
- Erroneous conclusions

Red = human influencing factors which are directly impacted by available automation technology
+ already applied in nuclear, aviation, …

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21st century approach of Automation

Operator = unavoidable source of errors and losses

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- **Technology = a tool to reduce the exposure of the process to human intervention and errors**
- **Operator error = caused by not following procedures and / or lack of competency**

Operator = unique source of safety and reliability

- **Unique human contribution = *manage abnormal situations*** (anticipate, detect, respond) **in process safety, reliability, …**
- **Automation objective = maximize the operator's impact on his process**
- **Technology is a tool to boost the *Human Reliability* of the operator**
- **Operator error = failure of operational and technical *management* to adapt work to human characteristics of operator**

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Human limitations for reliable alarm response

(norm EEUMA, measured by the ASM Consortium as upper bound)

Type of problem	Maximum target *per operator*
Standing alarms	<10
Background alarms	<10 per hour
Alarm flooding	<10 in first 10 minutes of upset

Beyond these limits, human operator response
is structurally unreliable

Allowing such installation to operate without compensating measures
is a management failure

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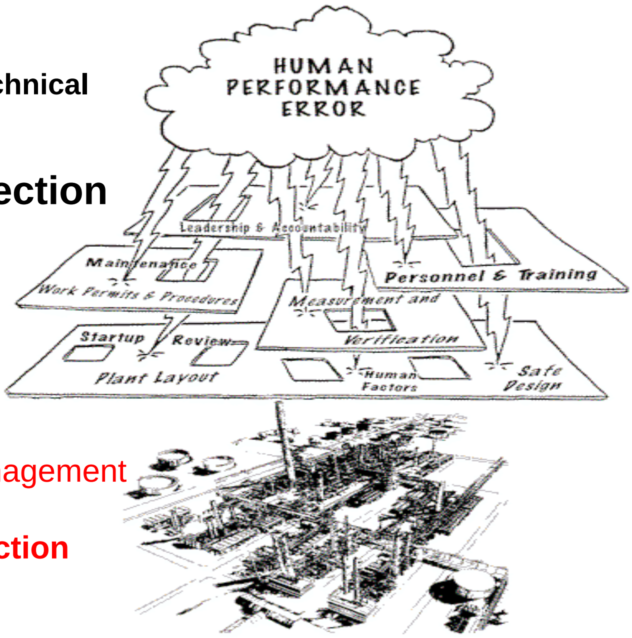
The role of Operational and Technical Management = installing

Layers of Protection



Effective alarm management
= a vital
Layer of Protection

Figure from CCPS website

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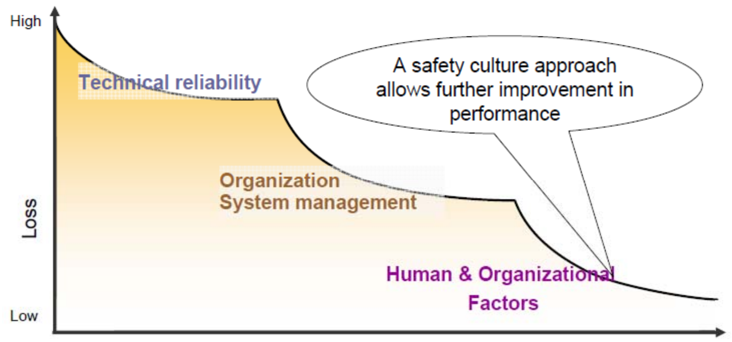
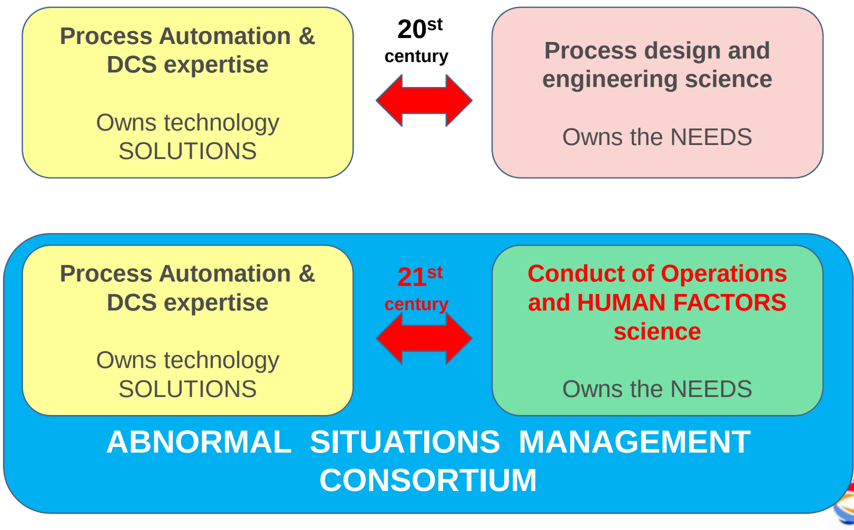
Alarm Management : part of Process Safety Culture and Operational Excellence

- Supporting the operator as unique source of safety and reliability
- Operations-centered approach : technology boosts human performance
- Operational professionalism as core competency



Transverse competencies remain THE *key element* for Automation success in the 21st century



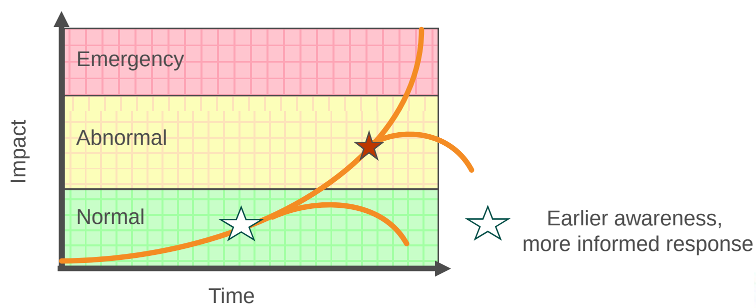
The state-of-the-Art “lab” for technology - enhanced Human Reliability of the Operator : Abnormal Situation Management® Consortium

- R&D consortium of 15 companies and universities
  - Initially co-funded by US Govt (NIST) +$16M for first 4 years
  - Jointly invested +50M$ over 15 years
  - Creating knowledge, tools and products designed to **prevent, detect and mitigate abnormal situations** that affect process safety in the control operations environment
- Charter
  - Stage 1 (1994-1998) : Research
  - Stage 2 (1999-2001) : Prototyping
  - Stage 3 (2002-2004) : Development
  - Stage 4 (2005-2008) : Deployment
- Deliverables
  - Technology, prototypes, guidelines, best practices, metrics, application knowledge, workshops, products

R&D domain of the ASM Consortium

- **Technology to radically enhance the operational teams’ capability to :**
  - Error-free **DETECT** indicators and precursors
  - Error-free **DECIDE** on appropriate course of actions
  - Error-free **RESPOND** and execute corrective actions

in order to PREVENT or MITIGATE any abnormal situation



How ?

- By focusing on following 7 areas

1. **Understanding ASM** - Focuses on issues that may lead to a better understanding of current incident causes providing insight to reduce future abnormal situations and to prepare operations teams accordingly
2. **Management Structure & Policy** - Focuses on the effect of management structure and policy on the ability of the operations team to prevent and respond appropriately to abnormal situations
3. **Training & Skill Development** - Focuses on the impact of training and skill development in mitigating and coping with abnormal situations
4. **Communications** - Focuses on communication issues among plant personnel and with the use of information technology under normal, abnormal and emergency situations
5. **Procedural Operations** - Focuses on all aspects of procedures used to accomplish important tasks at an industrial site, particularly startup/shutdown
6. **Control Building & Operations Environment** - Focuses on the impact of the control building environments on effective operations
7. **Process Monitoring, Control & Support** - Focuses on process monitoring, control and support applications for effective operations. It includes such aspects as alarm management and early event detection.

This will not only help to handle abnormal situations, but any situation

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Conclusions :

1. **After decades of automation, the human operator's unique and irreplaceable contribution has become to manage abnormal situations.**
2. **Automation solutions, interfaces and tools will only be effective if they take into account the 'hard' science of Human Factors. This science should become a core competency for automation engineers.**
3. **The challenge for the Process Automation profession in the 21st century will be, to use technology for a radical enhancement of the operator's *human reliability* and his impact on the process in all normal and abnormal situations.**
4. **The Abnormal Situation Management Consortium plays an essential role in advancing technology to boost the human reliability of the operator. In its pursuit for operational excellence, Total is proud to contribute as a member.**

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Process Safety is why you do it, …

Reliability is how you pay it !

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