TOTAL PETROCHEMICALS

Human Reliability in future operations

NG Downstream

Bremen, December 14th, 2011

TOTAL

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

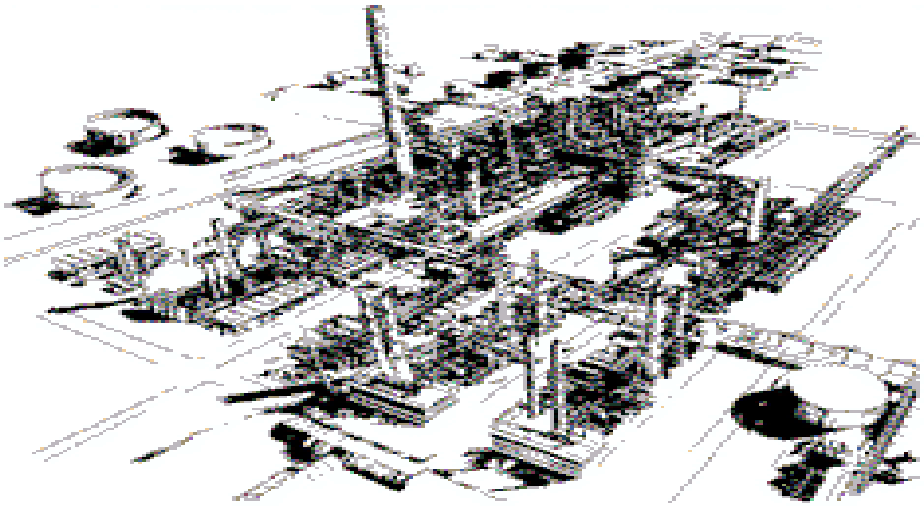
The dog is there to make sure

that the operator doesn't touch anything…

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…

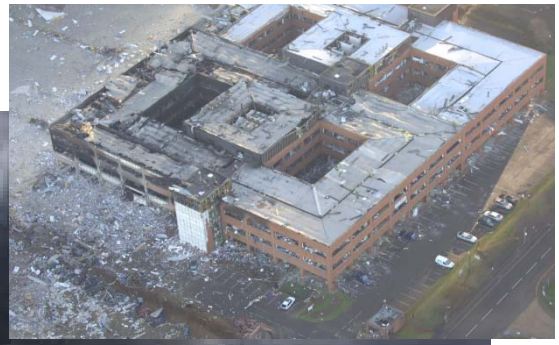


Just a matter of time and resources … ?

- **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”
  - …

TOTAL

21st century : several wake-up calls



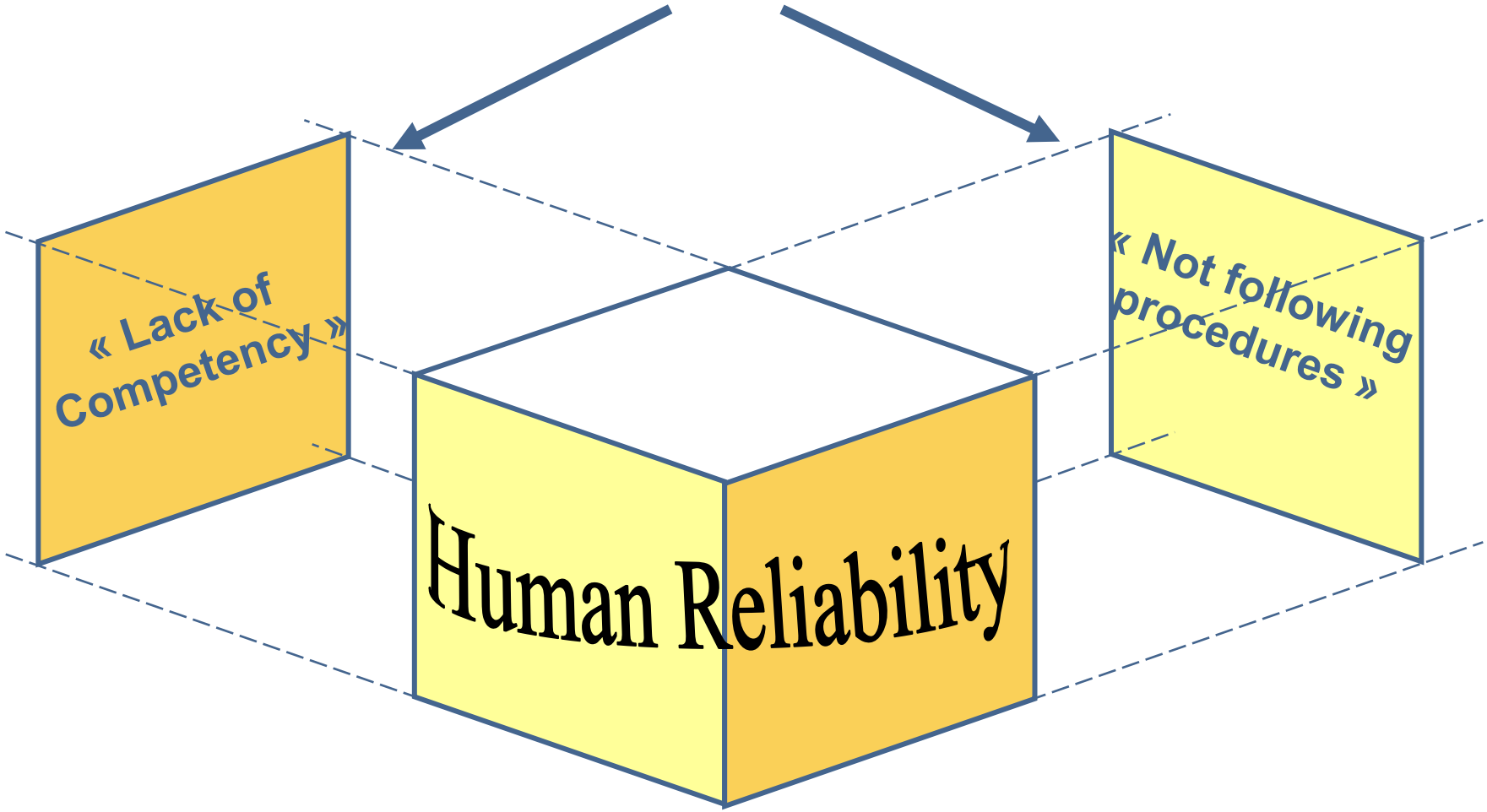
Classical (20st century) approach of Automation

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**

TOTAL

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**

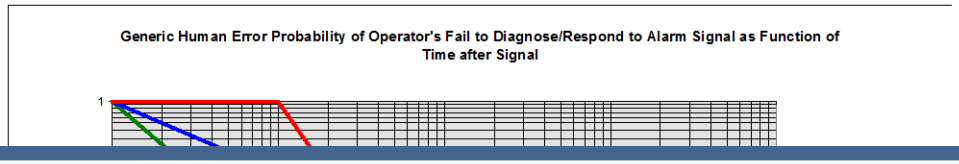
Human & Organisational Factors : domain

- **Basis = brain functioning**
  - Handling of conflicting priorities
  - Tunnel effect
  - Mental models during operations
  - …
- **Functioning of peer groups**
- **Quantified effects and limitations of human reliability :**
  - « double independant check »
  - time constraint on probability of operator error
  - Effect of personal signature
  - Length of procedures
  - Controls standardisation
  - Use of colors in operator displays
  - ….
- **Applications available :** nuclear sector, aviation, military...

Second checker

Effect of second checker on human error probability

Effect of time constraint



Length and use of checklists

Table 20-7 Estimated probabilities of errors of omission per item of instruction when use of written procedures is specified

Item	Omission of Item:	HEP	EF
	When procedures with check-off provisions are correctly used:		
(1)	Short list, ≤ 10 items	0.001	3
(2)	Long list, > 10 items	0.003	3
	When procedures without check-off provisions are used, or when available check-off provisions are incorrectly used:		
(3)	Short list, ≤ 10 items	0.003	3
(4)	Long list, > 10 items	0.01	3
(5)	When written procedures are available and should be used but are not used (i.e., rely on memory)	0.05	5

Human error = linked to specific nature of people

Required strategy =
- Understand human error

- *Reduce error-likeliness* by organizational and technical measures

- Strengthen the error recovery by the peers

- Continuous learning : active tracking of minor work errors and near misses

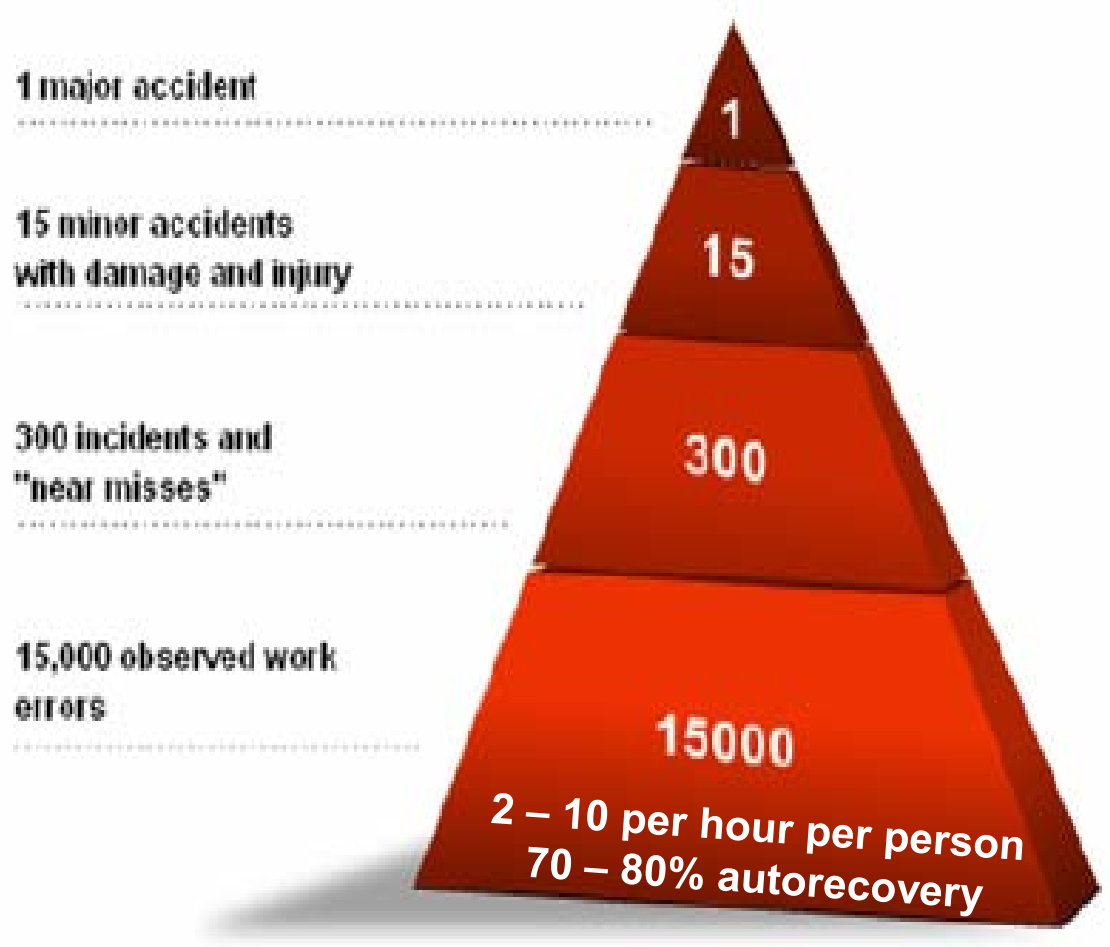
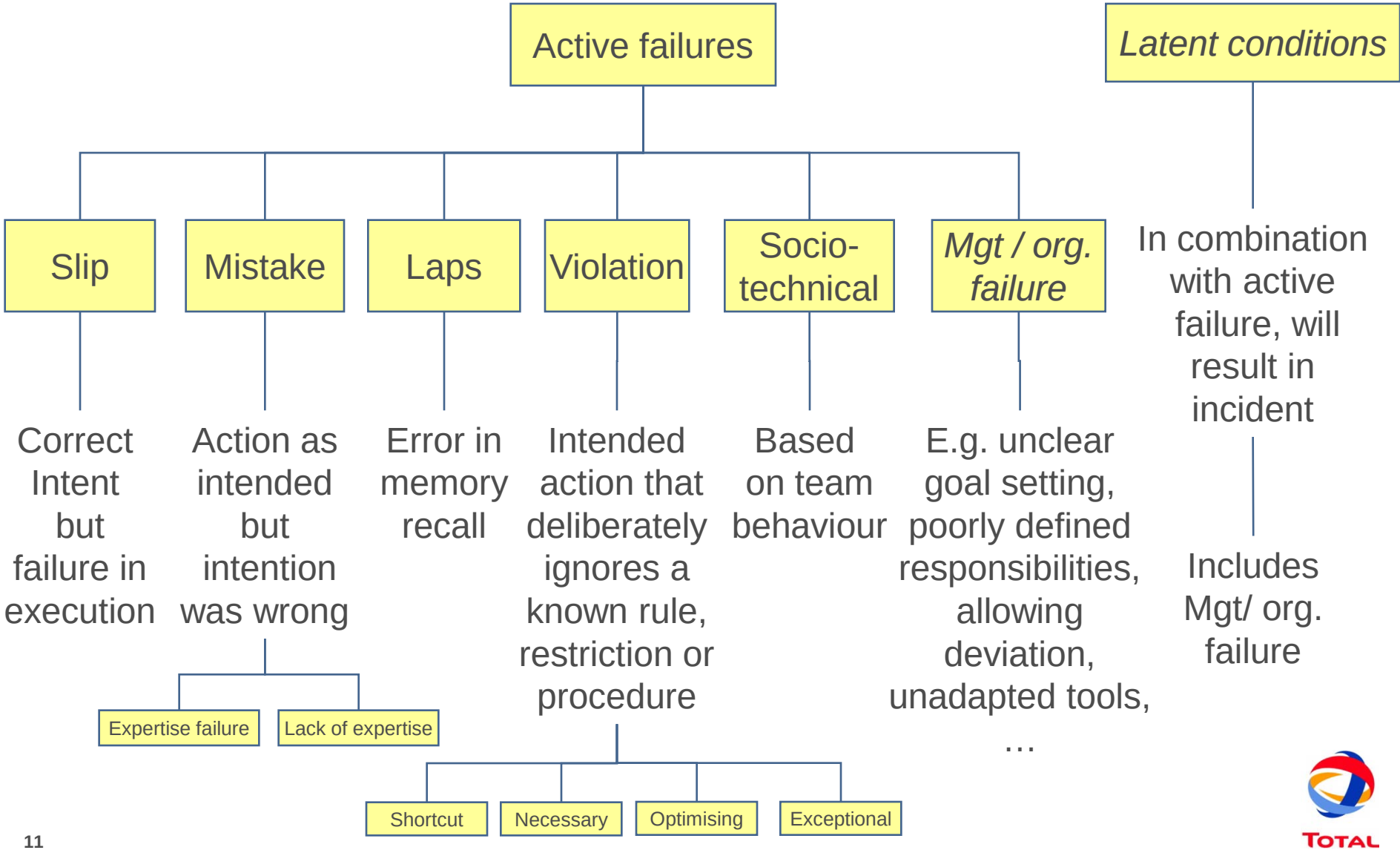


Figure from Honeywell & ASM Consortium

TOTAL

Human Error typology in the Process Industry :

Classification according to CCPS



The human ‘control loop’ of the operator

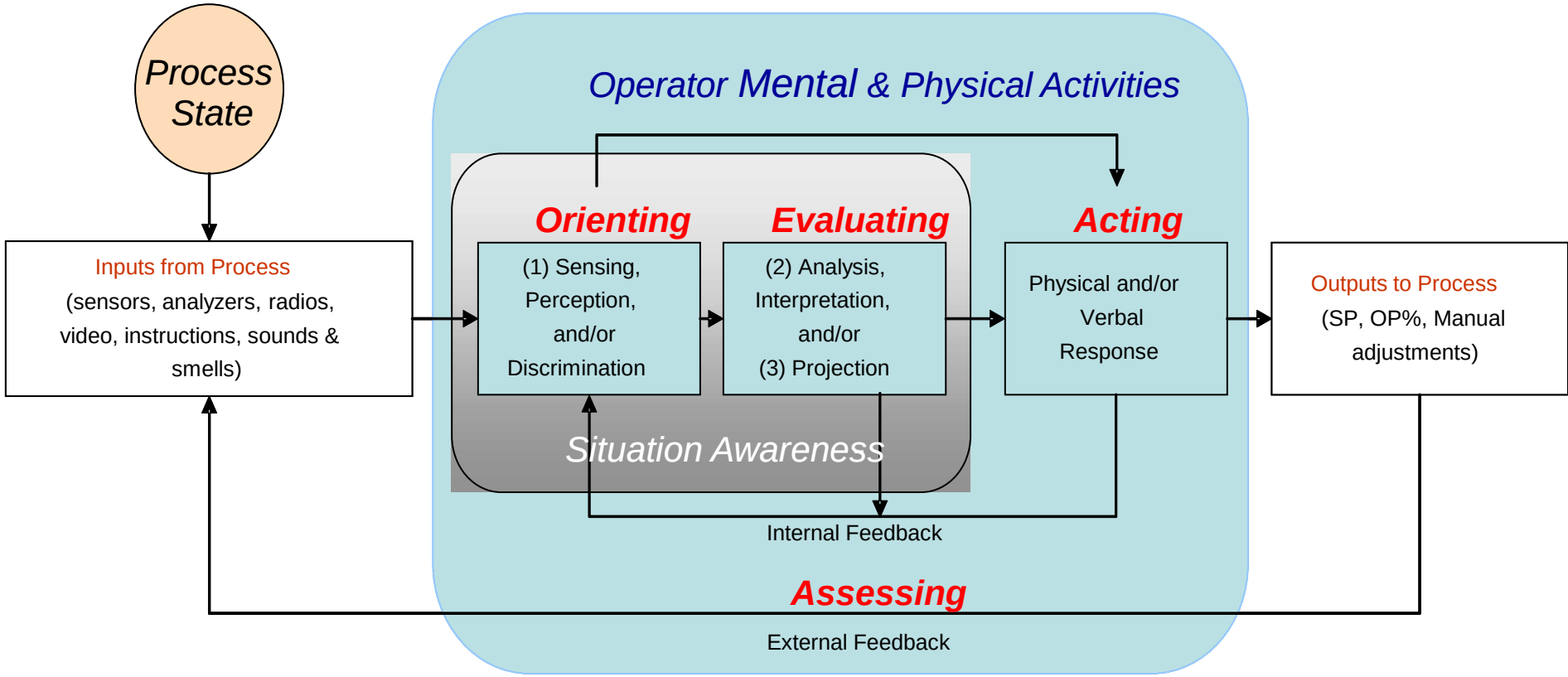


Figure from the ASM Consortium

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

TOTAL

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

- Lacking “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, …

TOTAL

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Operator = unique source of safety and reliability

- **Unique human contribution = *manage abnormal situations*** (anticipate, detect, respond) **in process safety, …**
- **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 organization and tools to the human characteristics of the operator**
- (more automation doesn't remove any operator functions…)

Transverse competencies remain KEY for Automation success also in the 21st century

Process Automation & DCS expertise

Owns technology SOLUTIONS

20st

Process design and engineering science

Owns the NEEDS

Process Automation & DCS expertise

Owns technology SOLUTIONS

21st

Conduct of Operations and HUMAN FACTORS science

Owns the NEEDS

TOTAL

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

ExxonMobil

sasol
reaching new frontiers

Shell

bp

TOTAL

ConocoPhillips

PENNSTATE

Human Centered Solutions
Helping People Perform

Mary Kay O'Connor
PROCESS SAFETY CENTER

NANYANG TECHNOLOGICAL UNIVERSITY

Honeywell
Process Solutions
Advanced Technology Labs
Specialty Materials

UOP

UCLA

ASM

- 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

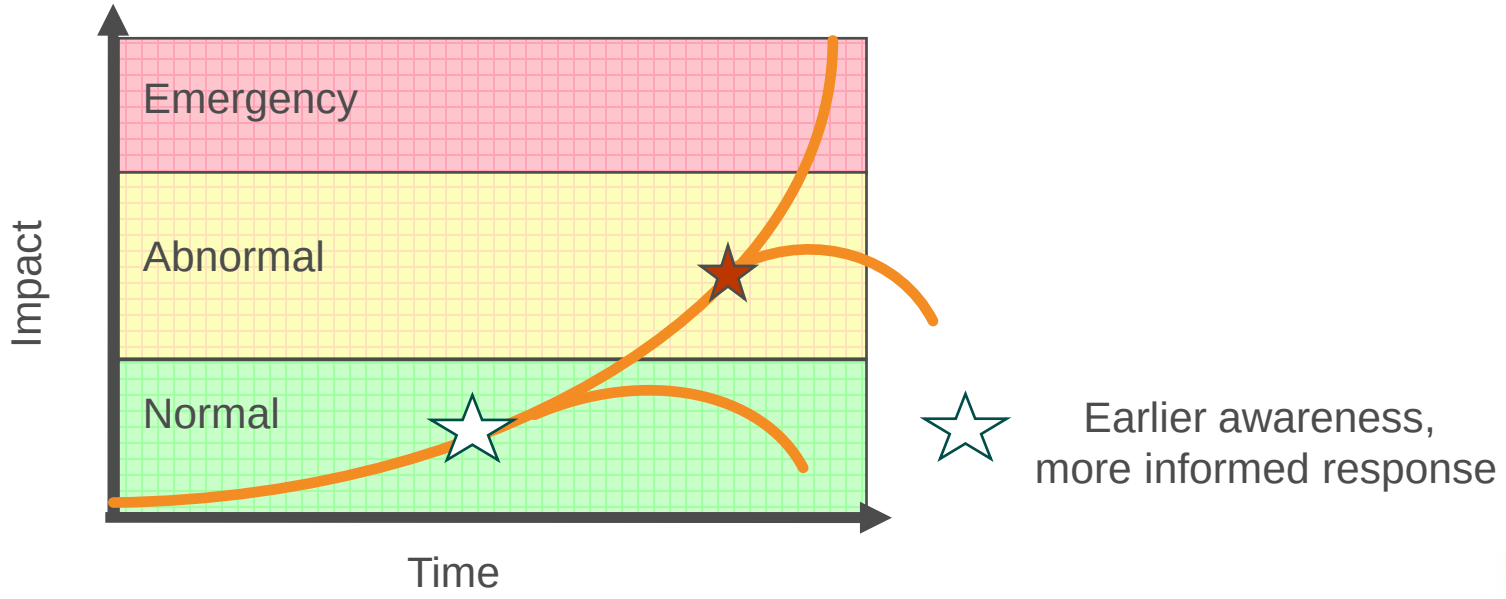
ASM
Designed for Abnormal Situation Management

TOTAL

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 <u>PREVENT</u> or <u>MITIGATE</u> any abnormal situation



Human and Organizational Factors : a mature and applied science, and an *largely untapped resource* for the Process Industry

- **The first users : marketeers …**

  Influencing the human decisions of their customers (while the Process Industry concentrated on reducing headcount ?)

- **Nuclear and Aviation industries !**

  They could only survive by improving their Human Reliability (while the Process Industry translated accidents and risk into an economic cost ?)

- **« High Reliability Organisations » (HRO)**

  Human Factors = core competency for them (while the Process Industry concentrated on technical competencies ?)

- **Process Industry ?**

  - Little generalized use of HF, but some interesting Best Practices can be observed …

Process Safety Officer (PSO)

- ***(Science :** the positive energy required for an individual or a team to succeed a difficult operation prevents the same brain(s) to make proper decisions for a conflicting priority – like process safety…)*

- **Solution : Process Safety Officer (PSO)**
  - = a dedicated function (brain) during planned and unplanned critical operations (incl. all startups, …)
  - whose sole purpose is to keep an oversight, check the proper conditions for carrying out the operation, and stop the operation if he feels that it is needed for process safety
  - The PSO is independant from the operation : does NOT participate to the proceeding of the operation

- **At the moment of execution of critical operations, a « PSO event » is formally declared**
  - Assigned PSO puts on **red vest**
  - Not required personnel leaves the operational area
  - Result = spontaneous higher level of concentration

Quality policy on procedure writing

- ***(Science :** a competent professional will be reluctant to use a training manual to support the execution of his task, because it suggest incompetency)*

- **Formal procedure policy : purpose of procedure = boost the operator's *Human Reliability*, to be used by *trained and competent* professionals only** (cfr. airline pilots)
  - NOT as training tool
  - NOT to compensate lack of competency
  - Main philosophy : the reliable human intervention will prevent the accident, not the SOP

- **Ensure complete separation between training and procedures**
  - Experienced operators would never use the procedure if it means « training »

- **Besides the Action Steps : only 4 standard types of messages**
  - P.S.O. REQUIRED FROM THIS POINT (/ P.S.O. NO LONGER REQUIRED)
  - CAUTION : …… (regarding safety)
  - WARNING : …… (regarding equipment damage)
  - NOTE : …… (general and basic technical information)

- **Style and format prescriptions (cfr. CCPS guideline)**

TOTAL

Operating Procedures criticality classification

- ***(Science :** Human reliability when executing a sequence of instructions is increased by a factor of 10 when following a procedure at hand compared to relying on memory, and by 100 when using a procedure with sign-off provision per item)*

- **Procedure criticality classification based on *human error likeliness***
  - Low frequency = high probability of human error
  - Complexity (information access, mental loading, physical loading, communications, stress)
  - Dynamic judgment : based on incidentology or changing team composition / experience

- **For critical procedures :**
  - Mandatory use « in hand » during operation
  - Signing off on each step + at the end
  - Critical phase : PSO presence required (start and end is indicated)
  - Indication of the need to execute the exact sequence, or that some parts can be done in parallel

- **Other procedures : also required to follow but no mandatory sign-off per step**

Use of « double independent check »

- ***(Science :** the presence of a second independant checker reduces the human error probability by a factor 100 !)*

- **Each manipulation of a safety element is double checked by a second operator** (cfr. Interaction pilot – copilot)
  - Valve under relief valve
  - Transmitter of SIS
  - …

- **Strong verification after opening of process**
  - Torque tags are attached to all flanges which have been opened
    - Indication of torque value and type of joint
    - Date + ID of person who tightened the flanges
  - After maintenance : signing off by both parties
    - Operator verifies together with maintenance the equipment status and all torque tags
  - Torque tags are gradually removed after being pressure tested (no more torque tags allowed when equipment is effectively taken in service)
  - Yellow lining : before start-up of unit which has been changed or opened for maintenance
    - 2 independent operators walk the entire P&ID(s) of the unit and mark in yellow all correspondent and in red all deviations.

Human process interface

- ***(Science :** the human brain's capability of information processing (qualitative / quantitative reading, recording, interpreting) is limited, function of time constraints and standardisation)*

- **Formal alarm rate policy in place :**
  - normal operations : max.1 alarm every 10 minutes
  - upset conditions : max.10 alarms every 10 minutes

- **Intelligent alarm processing by the DCS**
  - Prioritising / suppressing alarms

- **Alarm reduction project and workgroup in place**
  - Continuous alarm rate monitoring
  - Defining improvement initiatives
  - Defining unique standard alarm philosophy and controls design

- **Intuitive operator displays**
  - Use of colour for abnormal situations (normal = grey)

Conclusions towards future operations

- Human Reliability is a largely untapped improvement opportunity for the Process Industry
- Ensuring Human Reliability is the main mission of the Operational Management, through organisational and technical measures
- The science of Human & Organisational Factors a core competency for future Operational Management
- There is still a long way to go...

TOTAL