Are Machines Better Than Humans in a Crisis?

Galveston, Texas

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MORE PRODUCTION - LESS RISK!

Profile – Dr. Maurice J. Wilkins

- Head of Global Strategic Technology Marketing
- PhD Chemical Engineer, Fellow of the Institution for Measurement & Control
- Member of Process Automation Hall of Fame
- 34 years process automation experience
- Chair of ISA101 – HMI standard
- Member of ISA Standards and Practices Board
- Proposer and Managing Director of ISA106
  - Procedure Automation in Continuous Process Operations
- Past Chair of WBF and Tom Fisher Award Winner
- Worked for Exxon Chemical, Honeywell, KBC, Breakthrough Process Consulting, Millennium Specialty Chemicals, Lyondell, ARC & Yokogawa
- Strong expertise in leadership and team building, strategic consulting, batch control, procedure automation, APC, human factors, process analysis

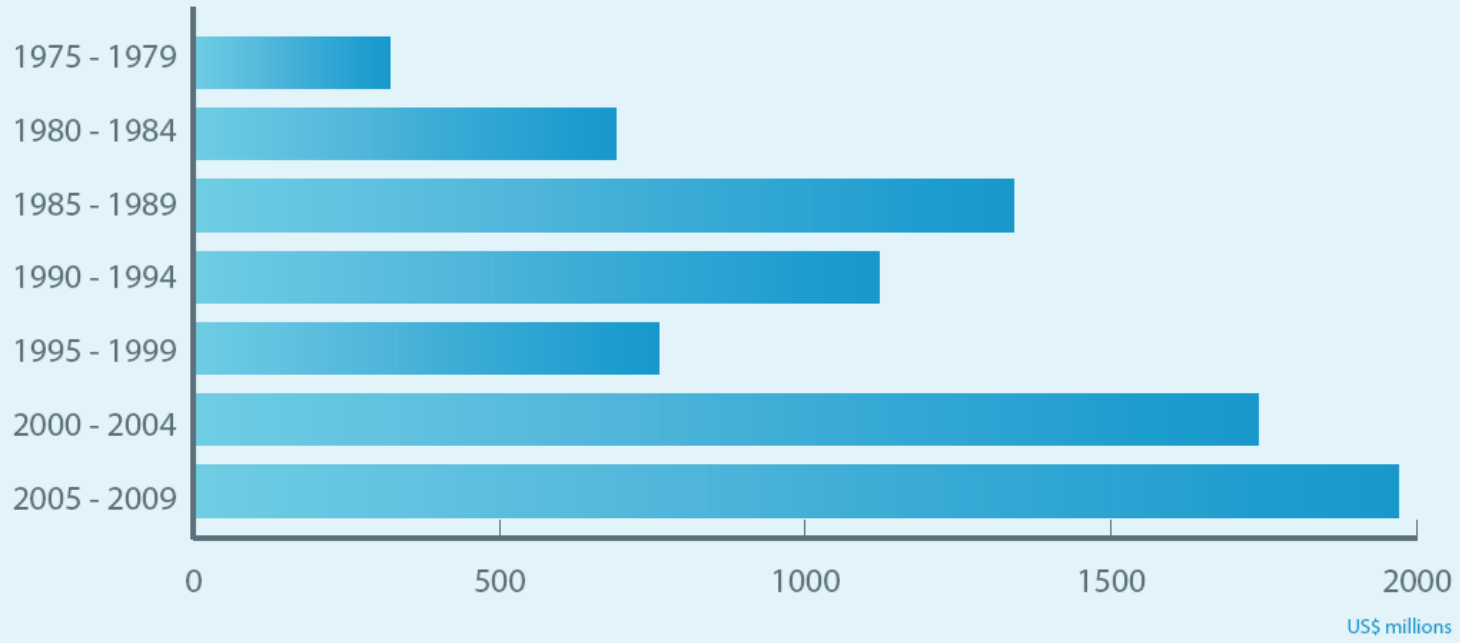
Agenda

- Challenges Affecting Process Operations
- Incidents – Can Operators Cope?
- Man versus Machine
- Operations Analysis
- Decision Support
- Standards Can Help
- Are Machines Better in a Crisis?

Refinery Losses Trend Upwards

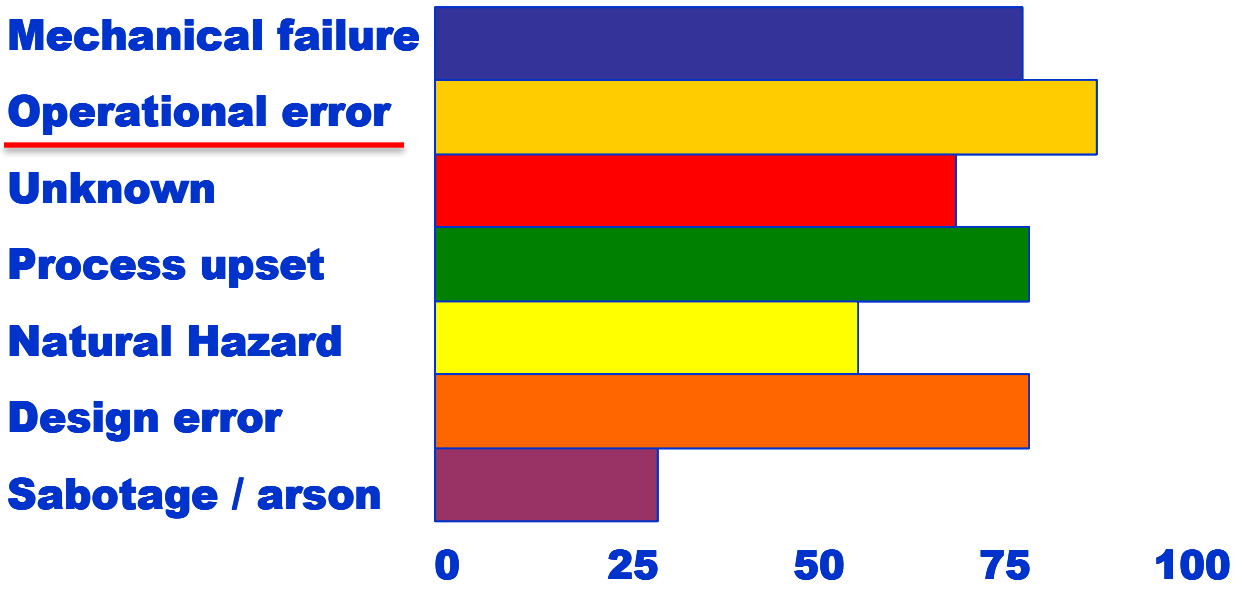
Large Property Damage Losses in the Hydrocarbon Industries (1972 – 2009)

Five year loss totals in the refinery industry have continued to trend upwards over the last few years. Piping failures or leaks (corrosion or incorrect metallurgy) and start-up and shut-down events continue to be significant causes.



Source: Marsh Associates

Average Loss Per Major Incident



Average Dollar Loss Per Major Incident by Cause
Millions of Dollars
Source: J & H Marsh & McLennan, Inc.

- At an average cost of $90 Million in losses per major incident, operational error is amongst the most expensive causes of error in production facilities

Today's Control Systems

- Safer environment and much better graphics
- Central control, data historians and automated systems
- But – far more data in a VERY configurable environment
- Systems can help but do today's operators get overwhelmed?
- How do you prevent this…

Can Operators Cope?

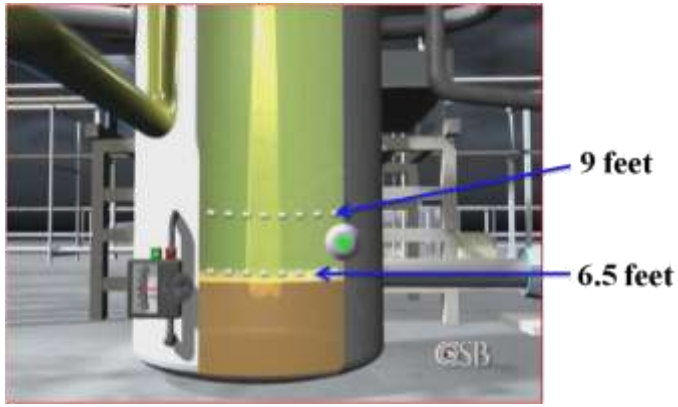
- Texaco, Milford Haven (1994) – "In the last 11 minutes before the explosion the two operators had to recognize, acknowledge and act on 275 alarms."
- Three Mile Island (1999) – "In the case of Three Mile Island, the principle cause was human error. If human operators had not misunderstood the situation and intervened inappropriately, the automatic systems would have averted the disaster"

BP Texas City

- **March 23rd, 2005**
- BP's biggest refinery
- Isomerization Unit
- Raffinate splitter tower
- 175 ft tall tower
- Distilled and separated gasoline compounds
- Major incident
- 15 killed and 170 injured

Procedure Issues

- Instrument checks not completed
  - Faulty hard wired alarm not repaired (no work order)
  - DCS high level alarm acknowledged and ignored – liquid was over the top level tap at start up
- Start up procedure issues:
  - Control valve closed in 'Manual' (should have been at 50% in 'Auto' per Start Up procedure)
    - During early start up this is the only way to control splitter level
  - Burners turned on prior to establishing rundown
  - Heat up ramp rate 50% higher than in procedure
  - Concern over pressures and temperatures but no clear answers



Consequences

- Several other procedures and concerns not addressed
- Hot liquid filled tower completely
  - Temperature profiles indicated that the level was above the feed tray
- Emergency relief valves opened sending 52 gallons of hot liquid to blow down drum
- Hydrocarbon geysers issued from top of blow down drum
- Vapor cloud ignited by pick-up truck
- Explosion!!!

BP Final Report

- Of 4 major causes – one was procedures
- "…failure to follow many established policies and procedures. Supervisors assigned to the unit were not present to ensure conformance with established procedures, which had become custom and practice on what was viewed as a routine operation"
- "The team found many areas where procedures, policies, and expected behaviors were not met"

Recommendations

- Modify startup and shutdown procedures
- Include steps to:
  - Notify personnel on all surrounding units
  - Evacuate all non essential personnel from the unit and surrounding area
  - Incorporate formal "go/no go" decision to proceed with charging feed
  - Ensure that operating procedures include safe upper and lower operating limits, and actions to correct deviations from the operating envelope
- Note
  - No recommendation for additional training
  - No recommendation for procedural support (although the plant was equipped with a DCS)

Should We Remove the Human?

- In the airliner of the future, the cockpit will be staffed by a crew of two--a pilot and a dog. The pilot will be there to feed the dog. The dog will be there to bite the pilot if he tries to touch anything -- *Commercial airline pilot*

Aviation Procedures

- In 1935, a prototype for the Boeing B-17 Flying Fortress crashed during takeoff at Wright Field in Dayton, Ohio
  - The cause of the crash was identified as a gust lock that was still engaged
  - Airplane was deemed 'Too complicated to fly'
- Test Pilots came up with checklists for takeoff, in flight, before landing and after landing
- Checklists have evolved into procedures integrated into flight systems making major contribution to aviation's safety record

Humans DO Count – Qantas Flight 32

- Largest commercial airliner
- Outbound from Singapore en route from London Heathrow to Sydney on Nov 4, 2010
- One of the engines blew apart over Indonesia
- The pilots were inundated with 54 computer messages alerting them of system failures or impending failures
- With only about eight to 10 messages able to fit on a computer screen, pilots watched as screens filled only to be replaced by new screens full of warnings

Humans DO Count – Qantas Flight 32

- It was just luck that there happened to be five experienced pilots (including three captains) aboard the plane that day
- The flight's captain was being given his annual check ride (a test of his piloting skills) by another captain
- That captain was himself being evaluated by a third captain
- Also first and second officers, part of the normal three-pilot team
- Even with five pilots working flat-out, it took 50 minutes to prioritize and work through each of the messages -- necessary steps to determine the status of the plane

Maybe There's a Balance?

- "Humans are doing a pretty good job, but they do it even better with the assistance of algorithms"
- "This research … is really showing the power of how, when algorithms work with humans, the whole system performs better"

Mary L Cummings

Associate Professor of Aeronautics and Astronautics Director, MIT

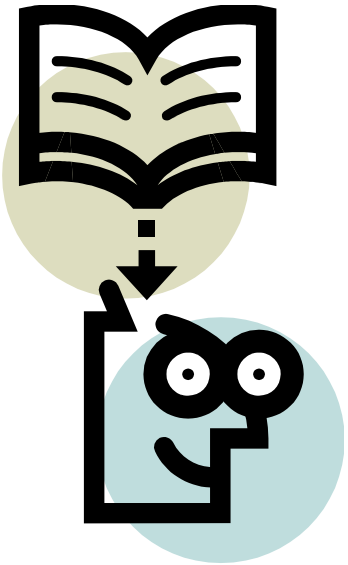
Research into human-automated path planning optimization and decision support

Finding the Balance

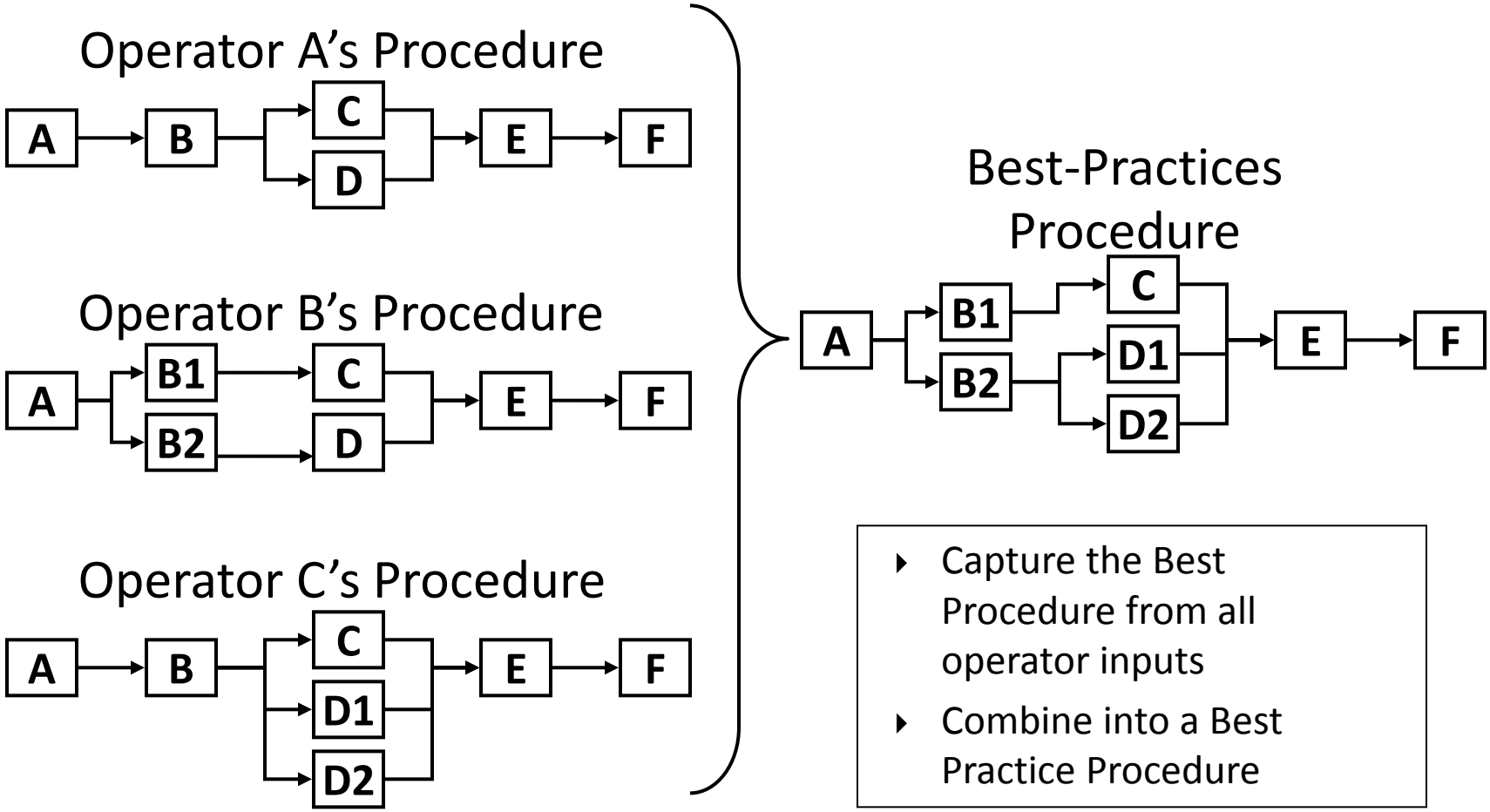
- Automated systems
  - Can do repetitive things over and over the same way
  - They don't fall asleep or ignore procedures
  - They don't panic under pressure
  - They can respond quickly to changes in conditions
  - BUT they can fail and they need "training"
- Humans
  - Are perceptive
  - Have senses
  - Can weigh pros and cons
  - Respond to advice…from automated systems

Capturing Procedural Knowledge

- Much "procedural knowledge" is in the heads of the most experienced operators
- They have their own tweaks that are often not in the SOPs or are their interpretation of an SOP
  - Maybe that ramp is not a direct ramp but a series
  - Always check this temperature while starting up
- Automated procedures can capture the knowledge of the best operator on his/her best day…every day
  - Remove shift to shift inconsistencies
  - Ensure that a procedural operation is being conducted safely



Aim to Capture Procedural Best Practices



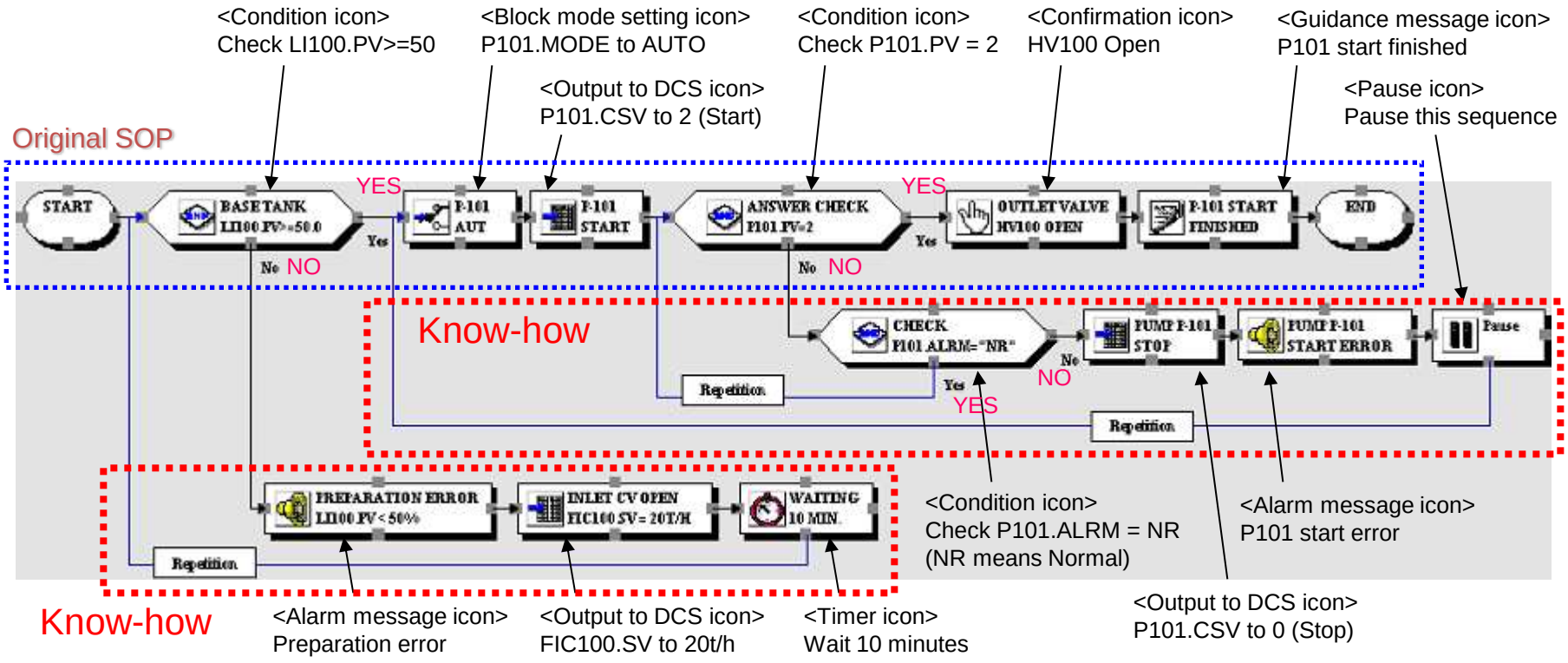
- Capture the Best Procedure from all operator inputs
- Combine into a Best Practice Procedure

Capturing Procedural Best Practices

Original SOP (Standard Operating Procedure)

(1) Check base tank level LI100.PV >= 50%
(2) Start pump P-101
(3) Check answer back flag
(4) Confirm field operator to open hand valve HV100

Capture Operator Knowledge!



Decision Analysis

- Assess the problem
- Collect and verify information
- Identify alternatives
- Anticipate consequences of decisions
- Making a choice using sound and logical judgment
- Based on available information

- A human in a crisis is not able to do this without help

Decision Support Systems

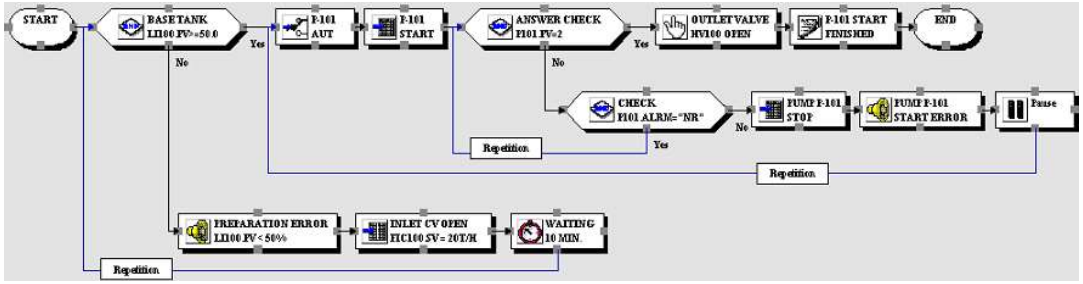
- Incorporate both data and models
- Uses historical data for 'memory' of what has happened in the past
- Designed to assist operators in semi-structured or unstructured decision-making processes
- Support, rather than replace, operator judgment
- Aimed at improving the effectiveness rather than efficiency of decisions

BP Texas City Revisited

- Operator overload, lack of confidence or taking procedures for granted?
- Operators would not have been alone with procedural assistance
  - Use of a procedural assistant could have helped unsure/overworked operators to take corrective action
- Procedural assistant could have given clear communications for all 3 units regarding
  - What had transpired during previous shifts
  - Next steps according to approved safety procedures
  - Safety hazards associated with missteps

Procedural Assistance

- Decision support from multiple aspects
  - Although level was ignored there was enough other information
  - Temperature information – profile and feed tray
  - Pressure information
  - Overheating in stripper bottom
  - Ramp rate too high
- The operators could not have digested all this information
- Procedural assistant could have triggered actions or prompts as a result of excessive liquid level
  - Alarms
  - Shutdown
  - Valve openings



ARE Humans Necessary in a Crisis?

- In times of abnormal operations, systems are configured to produce lots of data – humans are not configured to handle or interpret it
- Presented with the right data, humans can provide the "thought process" in a state of abnormal operations
- Automated systems can guide them or even take over in an emergency
- AND – would YOU fly in a plane without a pilot?

Thanks – Questions?

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