

# Abnormal Situation Management and the Human Side of Process Safety

**ERTC**

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Paper presented on behalf of the Abnormal Situation Management® R&D Consortium



# ASM Key Message

- In recent years, many organizations have been striving to improve process safety management performance.
- One opportunity for improving process safety performance is to **reduce the probability of human error through effective abnormal situation management practices.**



# Abnormal Situation Management®

A Joint Research and Development Consortium

Founded in 1994

Challenges associated with human side of process safety have been a focus of the Abnormal Situation Management® (ASM) Consortium for the past fifteen years.

[www.asmconsortium.org](http://www.asmconsortium.org)



**Honeywell**

**Human Centered Solutions**  
Helping People Perform

**ConocoPhillips**



**ExxonMobil**



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**PENNSTATE**



**UCLA**



**Shell**



**TOTAL**



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Enable operating teams to proactively manage their plants to maximize safety and minimize environmental impact while allowing the processes to be pushed to their optimal limits.

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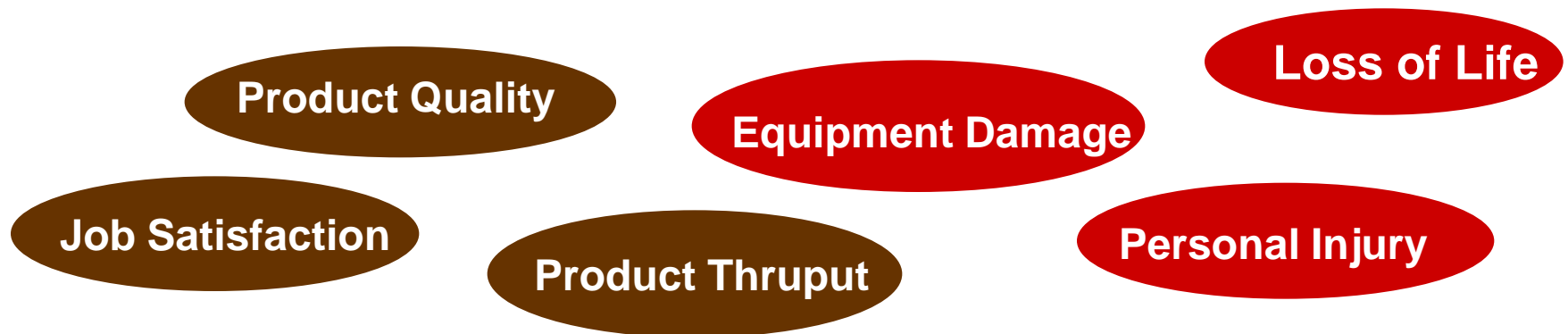
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# **ASM** *Abnormal Situation Definition*

- An industrial process is being disturbed and the **automated control system can not cope...**
- Consequently, the operations team must intervene to supplement the control system.
- Impacts **profitability** in multiple ways:





# ASM Relation to PSM

## Safety Pyramid Illustration

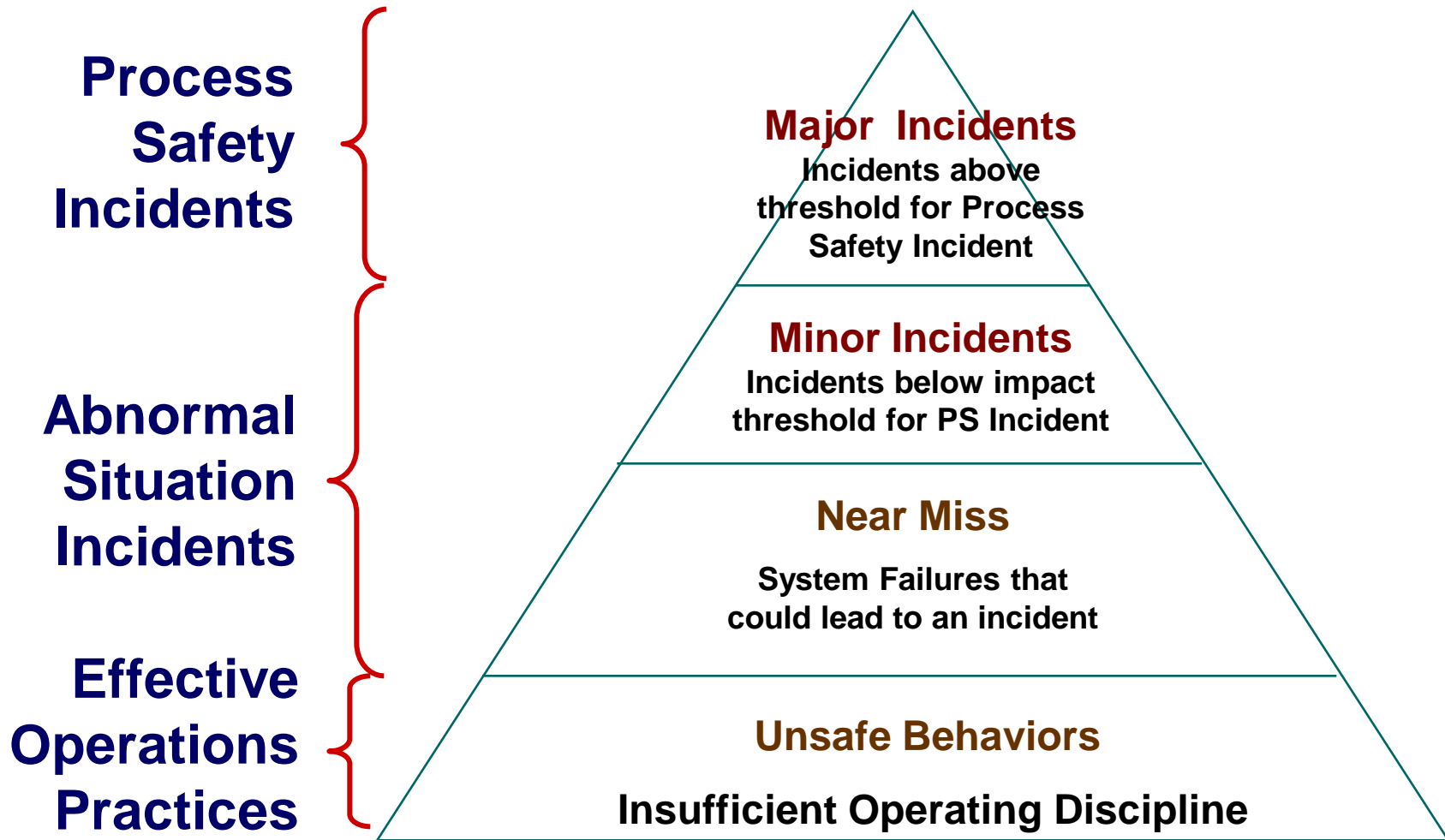


Illustration based on: CCPS *Process Safety Leading and Lagging Metrics*.



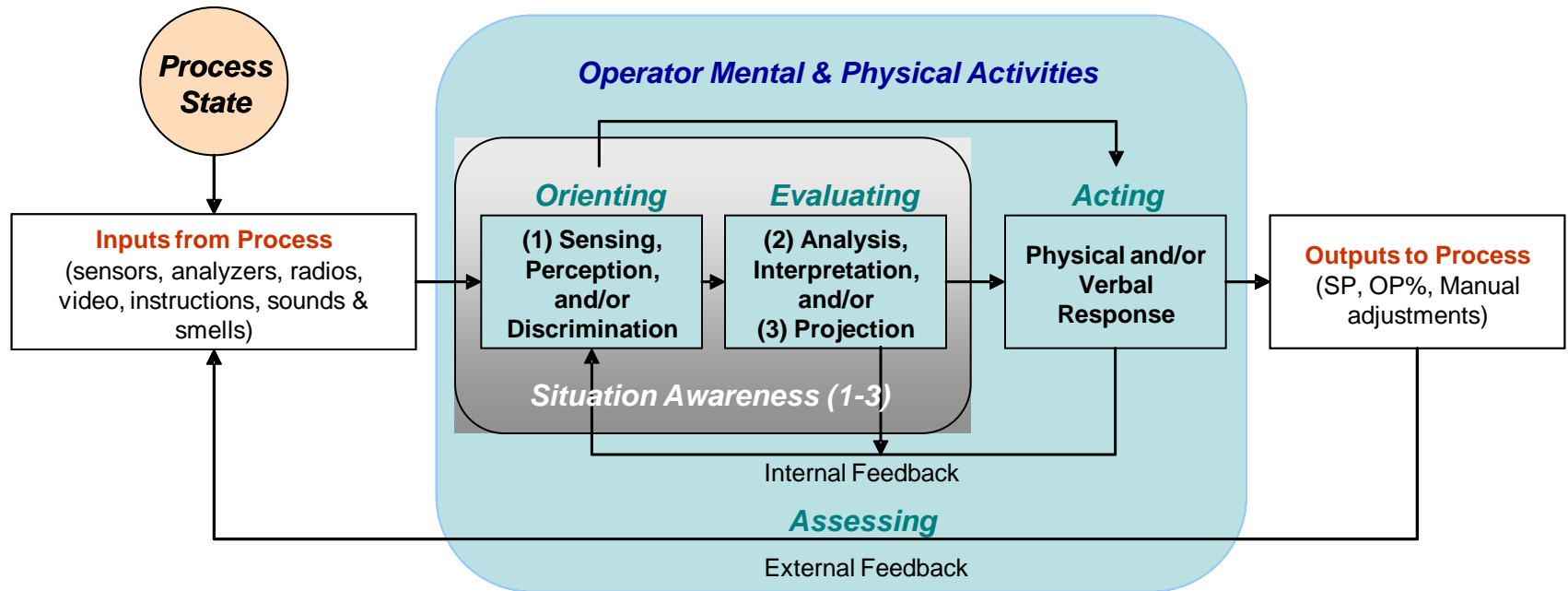
# Managing Abnormal Situations

## Operational Modes and Critical Systems Perspective

Operational Modes:	Plant States:	Critical Systems:	Operational Goals:	Plant Activities:
<b>Emergency</b>	Disaster	Area Emergency Response System	Minimize Impact	Firefighting First Aid Rescue
	Accident	Site Emergency Response System		
<b>Abnormal</b>	Out of Control	Physical and Mechanical Containment System  Safety Shutdown, Protective Systems, <b>Hardwired Emergency Alarms</b>	Bring to Safe State	Evacuation
	Abnormal	<b>DCS Alarm System</b>	Return to Normal	Manual Control & Troubleshooting
<b>Normal</b>	Normal	<b>Decision Support System</b> <b>Process Equipment,</b> <b>DCS, Automatic Controls</b> <b>Plant Management Systems</b>	Keep Normal	Preventative Monitoring & Testing

# Managing Abnormal Situations

## Human Supervisory Control

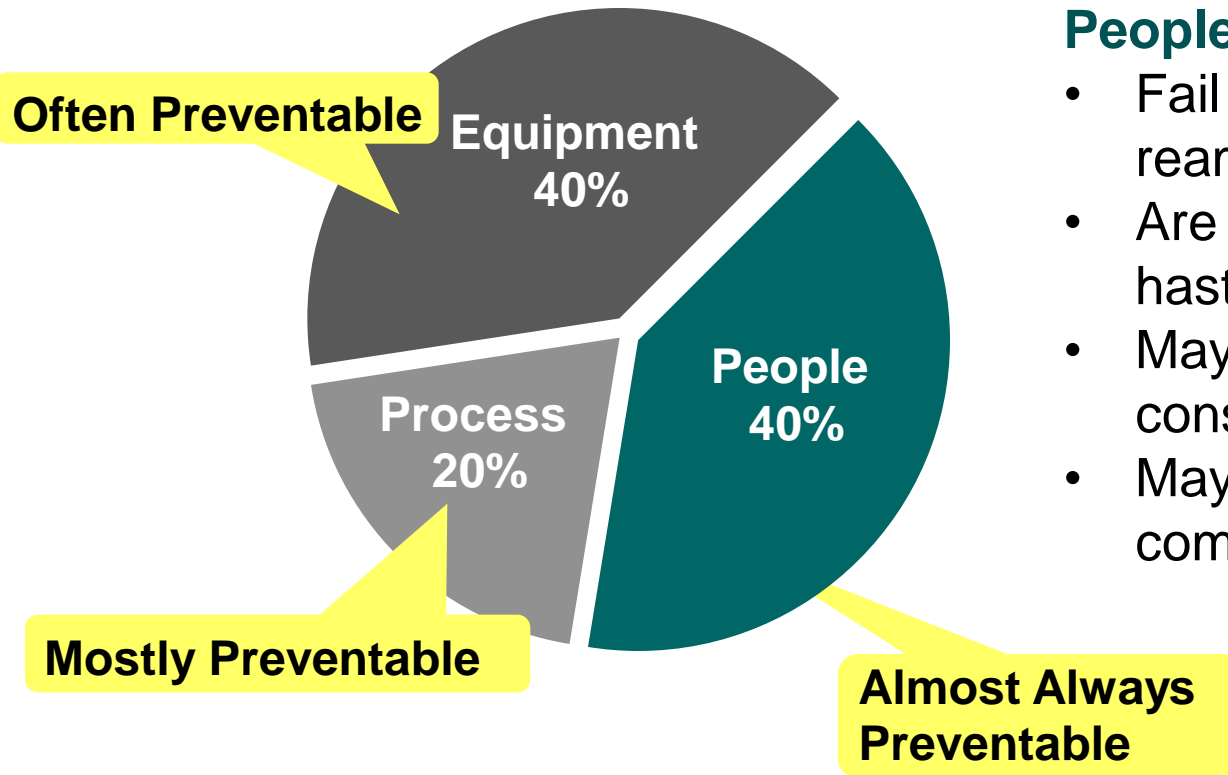


- This model operationalizes the human processing elements in the operator's supervisory control responsibilities for managing abnormal situations

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



## Sources of Abnormal Events



### People:

- Fail to detect problems in reams of data
- Are required to make hasty interventions
- May be unable to make consistent responses
- May be unable to communicate well

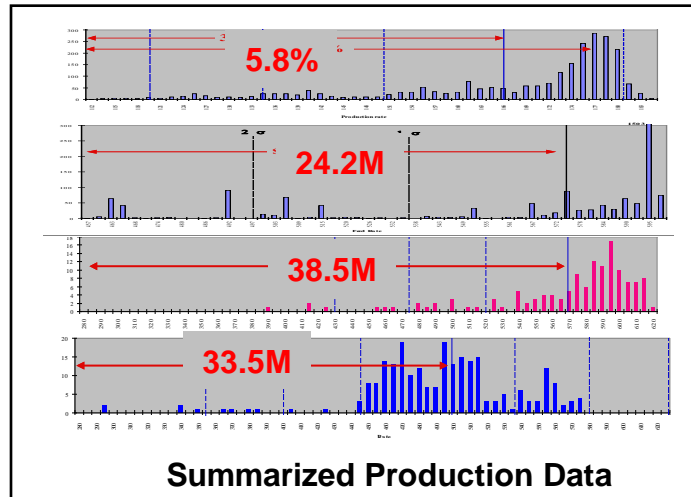
Established in literature ; confirmed by 18 plant studies - US, Canada, & Europe



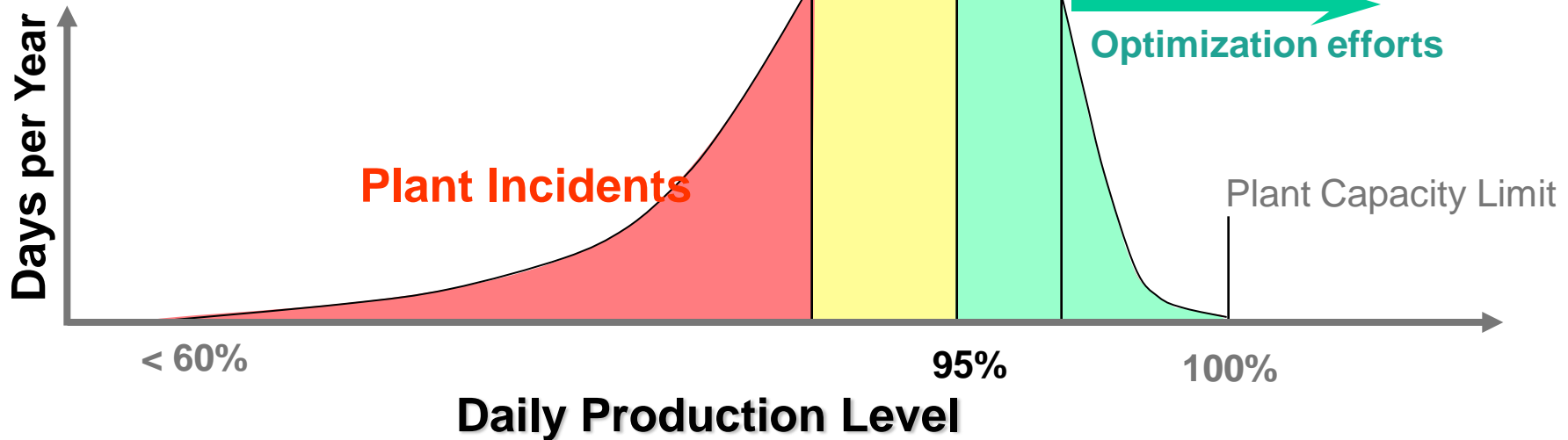
# ***Making the Business Case*** ***Unexpected Events Cost 3-8% of Capacity***

~ \$10 Billion annually in lost production !

Source: ASM Consortium Research



## **Plant Operating Target**



- **Paradox of Automation**

- Better automation leads to more sophisticated processes.
- More sophisticated processes leads to more opportunities for error.
- We tend to “fix” the increasing errors with still more automation.

- **Paradox of Reliability**

- Better equipment reliability leads to fewer operator interventions
- Fewer operator intervention leads to fewer opportunities to learn from experience
- Less experiential knowledge and skill leads to more human errors
- We attempt to “fix” the increasing human error with equipment reliability improvements

- ***Consequently, when things go wrong, people have difficulty intervening to correct the problem.***

- ***Need to better understand how to break the cycles and support human intervention activities***



# ASM Incident Analysis Study

## Project Objectives

- Understand relation between ineffective operations practices and process industry incidents
  - Systematically **analyze incidents** to determine common operational practice failure modes
  - Identify **root causes** of common operational practice failure modes
  - Why do failures occur ACROSS incidents

This research study was sponsored by the Abnormal Situation Management® (ASM®) Consortium.



# ASM Incident Analysis Study

## Common Operations Failures

Top 10 Operations Failures	#	%
Hazard analysis/ communication	79	15%
First-line leadership	65	12%
Continuous improvement	60	11%
Safety culture	36	7%
Initial and refresher training	30	6%
Task communications	29	5%
Comprehensive MOC	28	5%
Cross functional communication	23	4%
Compliance with procedures	15	3%
Design guidelines and standards	14	3%
Other failure modes	160	30%
<b>TOTAL</b>	<b>539</b>	

- 32 incidents were analyzed using TapRoot incident investigation methodology

	Public	Site	<i>Total</i>
USA	14	7	21
Non USA	6	5	11
<b>Total</b>	<b>20</b>	<b>12</b>	<b>32</b>

- Top 10 covered 70% of identified operations practice failures



# Root Cause Analysis Study

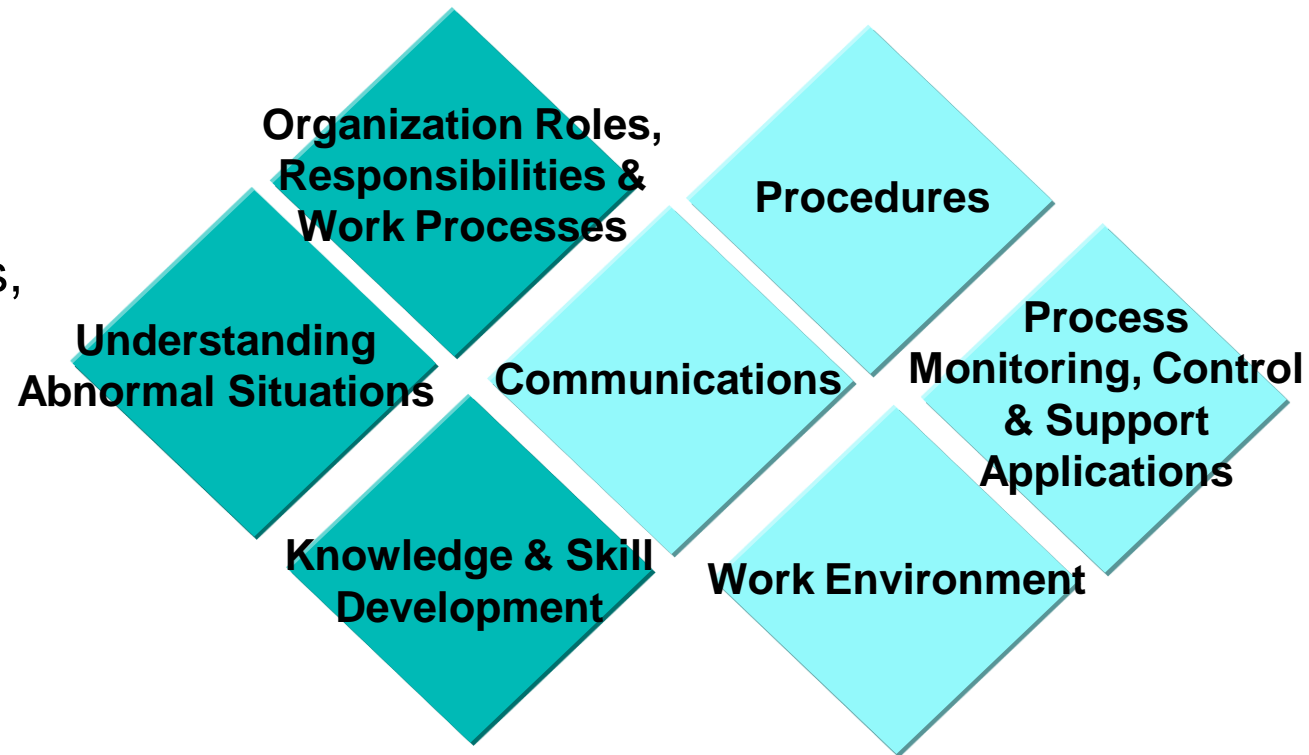
## Impact by Practice Areas

Effective Operations Practice Area	% of Failures
Understanding Abnormal Situations	4%
Organization Roles, Resp. & Work Processes	53%
Knowledge & Skill Development	7%
Communications	17%
Procedures	8%
Work Environment	1%
Process Monitoring, Ctrl, & Support Applications	10%

- Based on a total of **539 practice failures** across 32 incident reports

# **A Key to Success** **ASM Solution Framework**

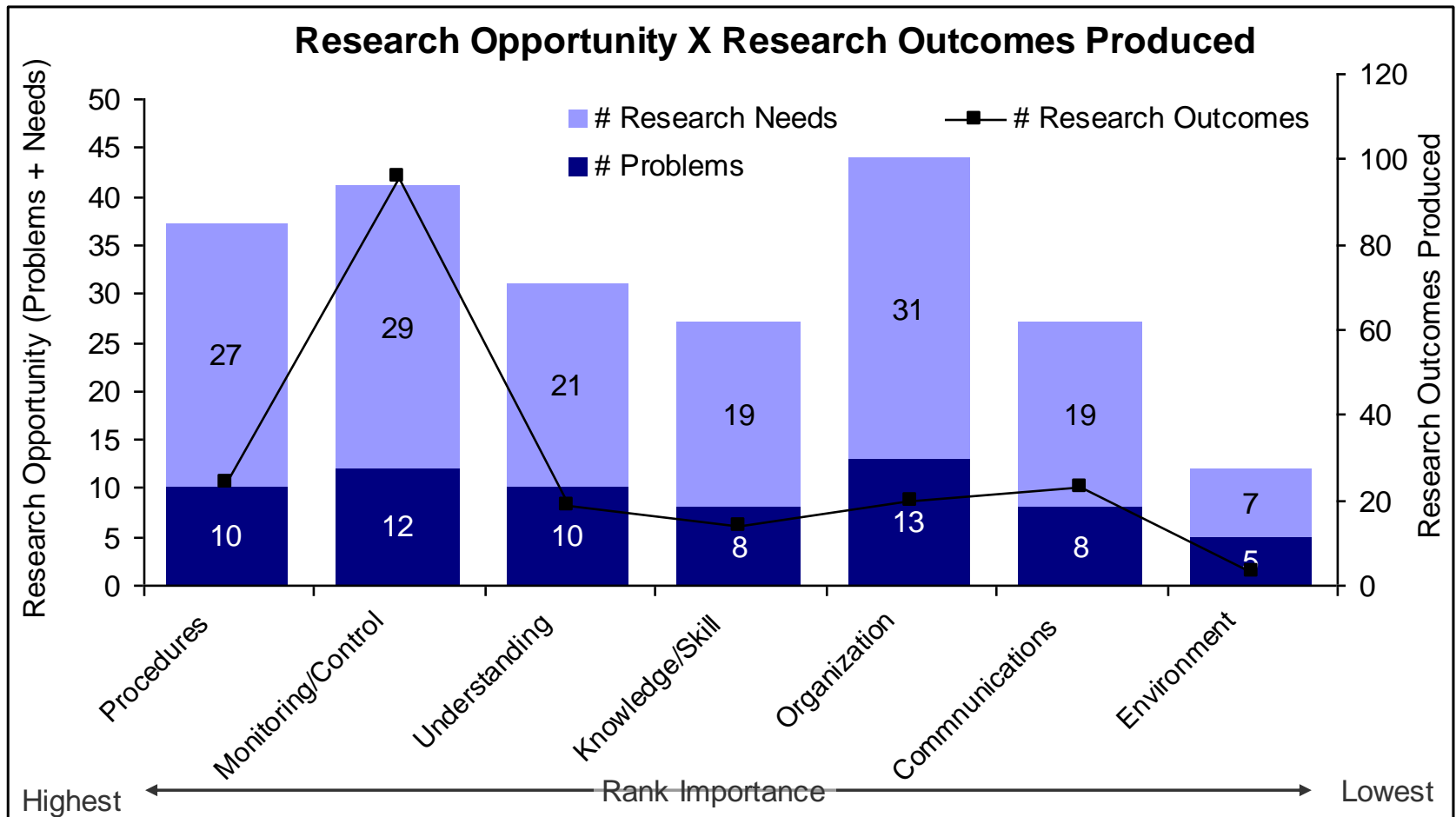
- Human reliability improvements require focus on more than technology
- We need to identify the problems that have to be solved and only then search for solutions:
  - Culture,
  - Organization,
  - Work place,
  - Work process,
  - and
  - Technology





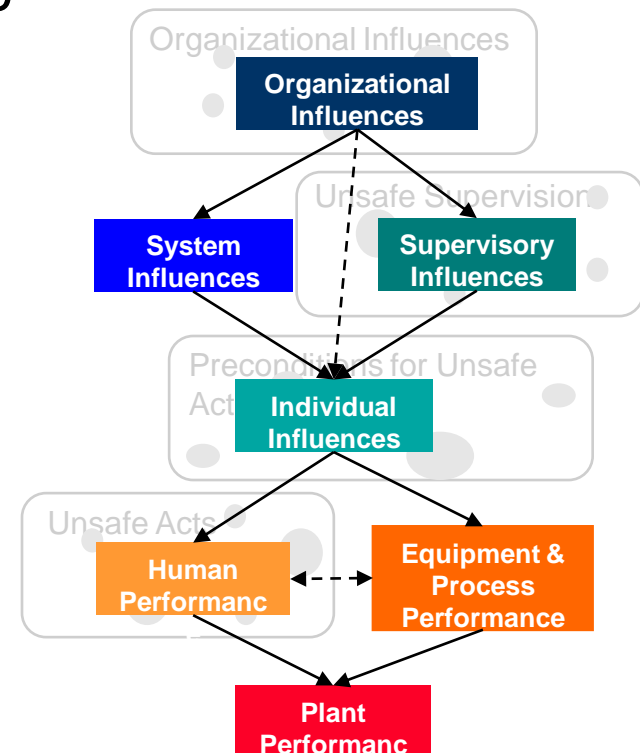
# Summary of Research Program

- 2009-10 Research Roadmap Analysis Findings vs. Past Research Outcomes illustrates areas of emphasis





- Shared understanding of abnormal situation causes and impacts, widely communicated across the site, in order to efficiently and accurately inform continuous improvement programs that mitigate and reduce abnormal situations.
- *Example project:* **Business Justification and Metrics Development**
  - Develop a conceptual cause and effect framework for analysis of impact of operations practices on operator and plant performance

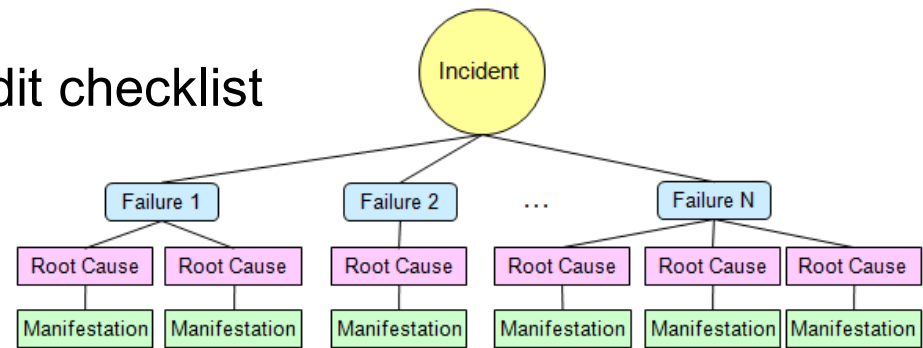
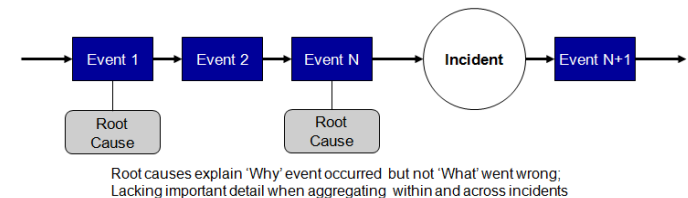


# Organization Roles, Responsibilities & Work Processes Vision

- Management systems, work practices, organizational structures, and a continuous improvement culture that supports prevention and mitigation of abnormal situations.

- *Example project:* **Root Cause Analysis of Industry Incident Reports**

- Develop understanding of operations practice failures in 32 industry incident reports
- Create plant manager's audit checklist



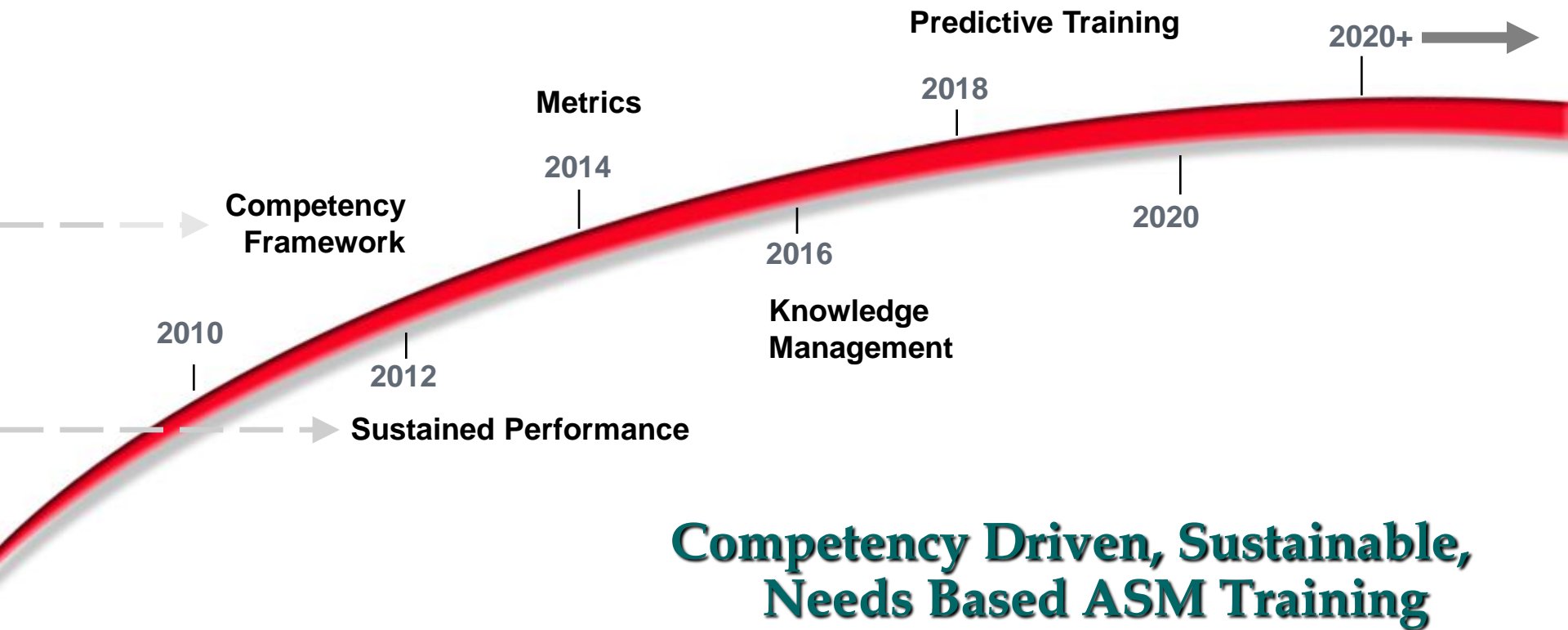
# **ASM Knowledge & Skill Development Vision**

- Knowledge and skill development **establishes and maintains the competencies** needed for effective abnormal situation response.
- Knowledge and skill development is a **continuous process** that is supported by a performance evaluation framework that identifies training opportunities and **enables sustainable operator performance** over time.
- *Example project:* **Use of Simulators to Train ASM Competencies**
  - Demonstrate effective use of simulators to train ASM competencies





# Knowledge & Skill Development Research Roadmap



# **ASM Communications Vision**

- Successful communication enables situation awareness under normal, abnormal and emergency situations.
- Communications practices allow operational and functional team members to efficiently perceive, orient, evaluate and act on information in context to the current team goals and constraints.
- Team members coordinate with respect to goals and activities, through the use of effective information media to ensure continuity in work conditions.
- *Example project:* **Use of checklist to improve shift handover communications**
  - Assess impact of handover checklist with structured electronic logbook



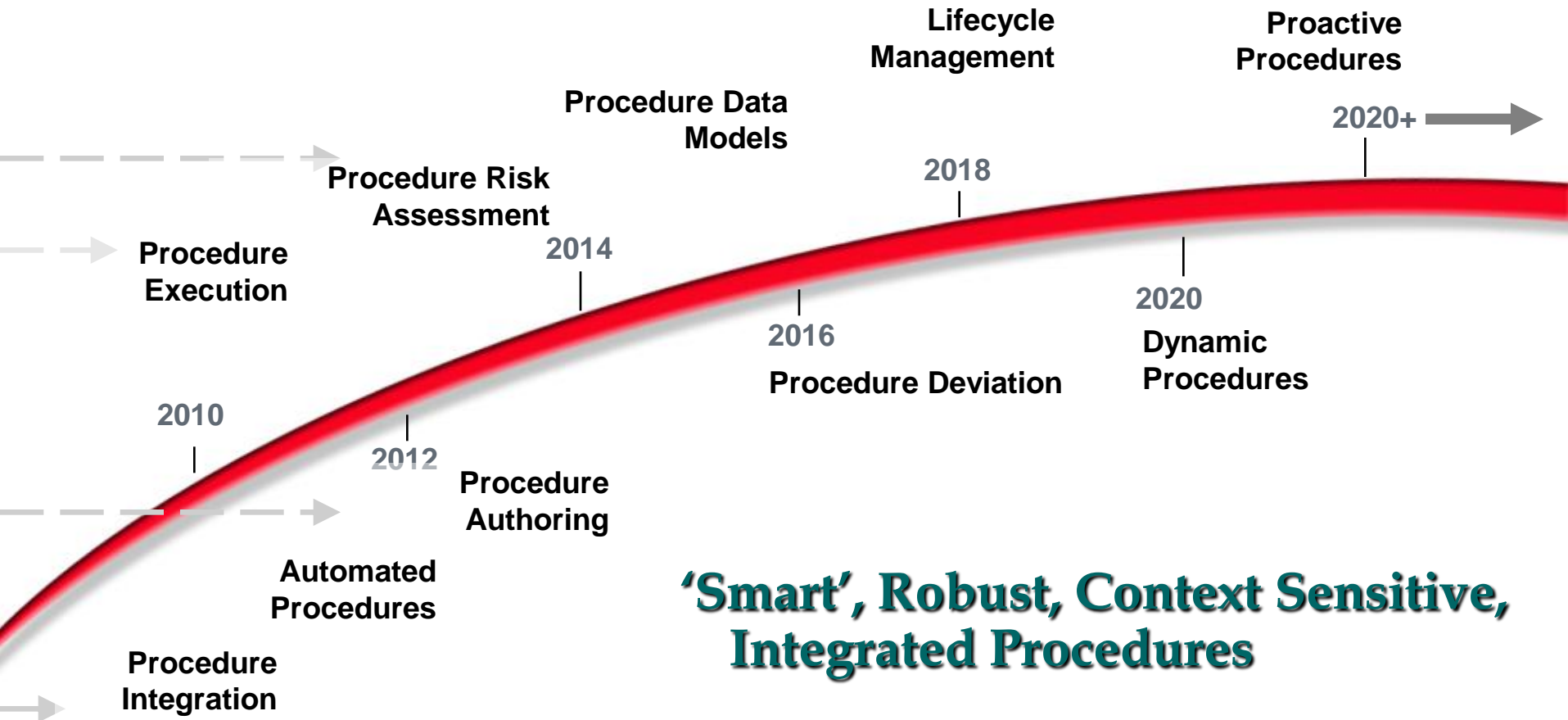
# **ASM Procedures Vision**

- Procedure content (whether automated or manual) is up-to-date and provides the guidance and instruction needed to minimize, avoid and recover from deviations in operating intent, including unexpected outcomes and abnormal situations.
- A comprehensive usage policy and procedure development, deployment, analysis, and lifecycle management practices enable effective procedure use in appropriate situations.
- *Example project:* **Procedure Execution Failure Modes during Abnormal Situations**
  - Understand how and why failures occur
  - Identify solutions to mitigate failures

Common Manifestations	#
Inappropriate action	15
Fail to detect abnormal condition	12
Lack understanding of impact	8
Fail to detect abnormal situation	4
Unaware of hazard	1
Total	40

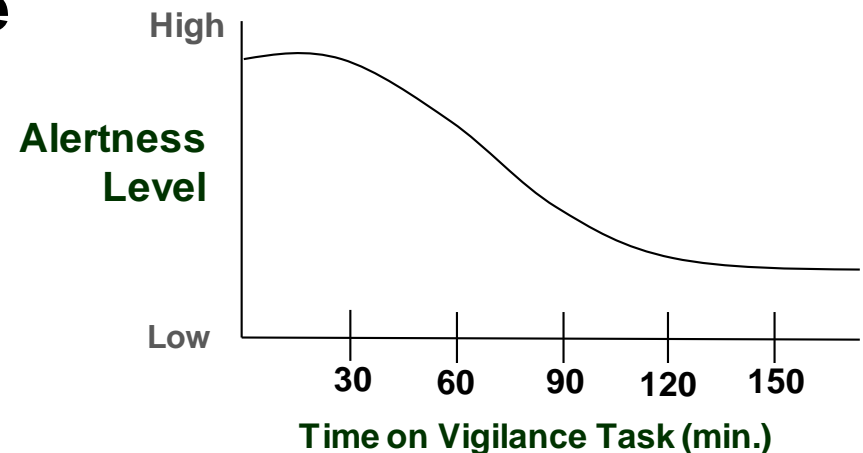


# Procedures Research Roadmap



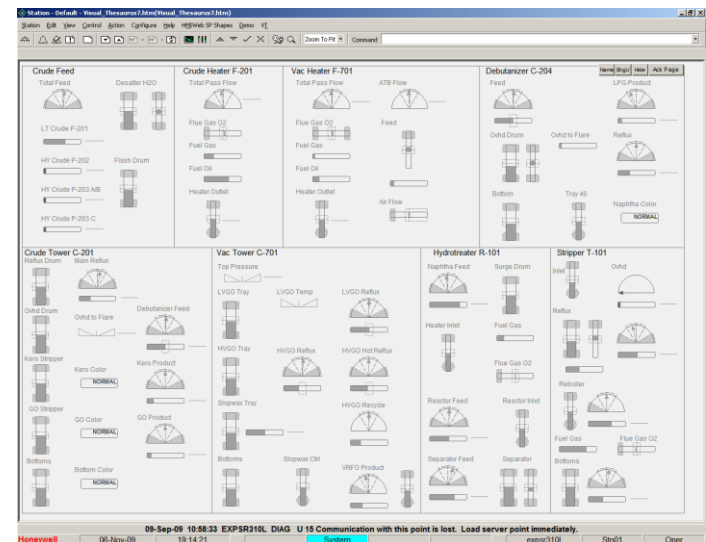
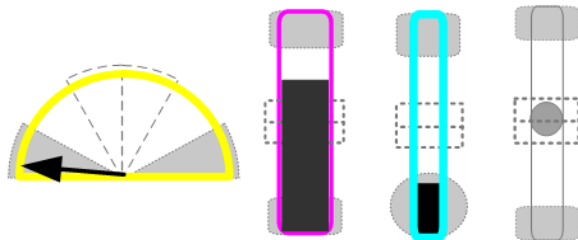


- The work environment enhances operations team situation awareness within their scope of responsibility, operator alertness, efficient work practices, collaborative interactions (including with other disciplines) and abnormal situation prevention and response.
- *Example project:* **Vigilance Decrement on Alertness**
  - Understand time course of alertness loss with console operations activity



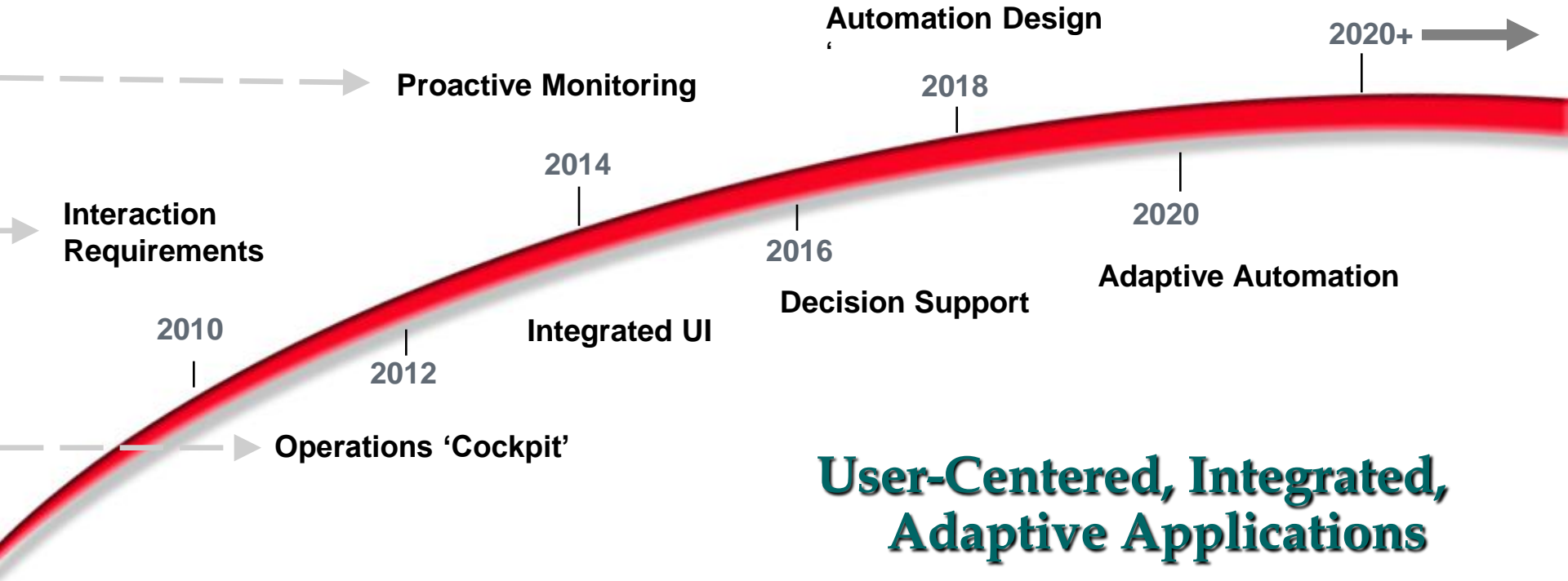


- A comprehensive and **user-centered** set of applications and tools that enables a **single point of access to the information** needed for operations **team situation awareness** and effective prevention and response to abnormal situations.
- *Example project:* **Visual Thesaurus**
  - Develop feasible and effective visualization techniques for console-wide overview displays





# Process Monitoring, Control, & Support Apps. Research Roadmap



# ASM ASM Guideline Documents



- Recently published for use in process industries
- Emphasis on effective prevention and response to abnormal situations
- Based on observed effective practices in member production facilities
- Includes learning from research projects

- **Understanding Abnormal Situations**

- Bullemer, P.T. and Laberge, J.C. (2010). Common operations failure modes in the process industries. *Journal of Loss Prevention in the Process Industries*. Elsevier. In press.
- Bullemer, P.T. (2009) *Better metrics for improving human reliability in process safety*. Paper presented in the 11th Process Safety Symposium at the 5th Global Congress on Process Safety, Tampa, FL.

- **Organizational roles, responsibilities and processes**

- Bloom, C. P., Barreth, R. & McLain, R. (2007). A rational methodology for conducting operations staffing assessments. *Proceedings of the NPRA 2007 Annual Meeting*.
- Bullemer, P.T., Jiron, S. and Nimmo, I. (2004). Shaping the future role of the operator. *Chemical Engineering Progress*. 100 (5), May 2004.

- **Knowledge and Skill Development**

- Bloom, C. P., Bullemer, P.T., Barreth, R. & Reising, D.C. (2010). Situation awareness for refining and petrochemical process operators – Not by technology alone. *Proceedings of the 2010 NPRA Annual Meeting*, Phoenix, AZ.
- Laberge, J., Thiruvengada, H. & Thrananthan, A. (2010). Improving board operator performance with simulator based training. *Tech and More*, Summer 2010, Issue 9.
- Bullemer, P.T., and Nimmo, I. (1996). A Training Perspective on Abnormal Situation Management: Establishing an Enhanced Learning Environment. *Proceedings of the 1996 AIChE conference on Process Plant Safety*, Houston, TX.

- **Communications**

- Laberge, J. C., Bullemer, P.T. and Whitlow, S. D. (2008). Communication and coordination failures in the process industries. *Proceedings of the Human Factors and Ergonomics Society 52nd Annual Meeting*, New York, NY
- Bullemer, P.T., Cochran, E., Harp, S & Miller, C. (1999). *Collaborative decision support for operations personnel*. Paper presented at the INTERKAMMA ISA Technical Conference, Dusseldorf, Germany.

- **Procedures**

- Bullemer, P.T., Kiff, L. and Tharanathan, A. (2010). Common procedural execution failure modes during abnormal situations. Presentation at Mary Kay O'Conner Process Safety Center International Symposium. College Station, TX.
- Bullemer, P.T. and Hajdukiewicz, J. (2004). A study of effective procedural practices in refining and chemical operations. *Proceedings of the Human Factors and Ergonomics Society's 48th Annual Meeting*. New Orleans, La, September 20-24, 2004.

- **Environment**

- Bloom, C.P., Bullemer, P.T., and Reising, D.C. (2010). *The interaction between large screen technologies, overview displays & effective control room layout: A workshop*. Paper presented at the International Control Room Design Conference, Paris, FR.
- Bullemer, P.T., Cochran, E., & Millner, P. (1999). Effective control center design for a better operating environment. *Proceedings of NPRA Computer Conference*, Kansas City, MO.

## • Process Monitoring, Control & Support Applications

- Reising, D.C., Laberge, J. and Bullemer, P.T. (2010). *Supporting operator situation awareness with overview displays: A series of studies on information vs. visualization requirements*. Paper presented at the International Control Room Design Conference, Paris, FR.
- Reising, D. C. & Montgomery, T. (2005). Achieving effective alarm system performance: Results of ASM Consortium benchmarking against the EEMUA guide for alarm systems. *Proceedings of the 20<sup>th</sup> Annual CCPS international Conference*, Atlanta, GA, April 11-13.
- Reising, D. C., Errington, J., Bullemer, P., DeMaere, T., & Harris, K. (2005). *Establishing operator performance improvements and economic benefit for an ASM® operator interface*. Paper presented at the NPRA Plant Automation & Decision Support conference, Grapevine, TX, October 18-21.
- Errington, J., DeMaere, T., & Reising, D. (2004). *After the alarm rationalization: Managing the DCS alarm system*. Paper presented at the AIChE 2004 Spring Meeting, New Orleans, LA, April 25-29.
- Bell, M., Errington, J., Reising, D. & Mylaraswamy, D. (2003). *Early event detection: A prototype implementation*. Paper presented at Honeywell Users Group 2003, June 9-13, Phoenix, AZ.
- Soken, N., Bullemer, P.T., Ramanathan, P., and Reinhart, B. (1995). Human-computer interaction requirements for managing abnormal situations in chemical process industries. *Proceedings of the ASME Symposium on Computers in Engineering*, Houston, TX.





# ASM Concluding Comment

- The ability of a plant to **effectively prevent and respond to abnormal situations** is a key element to reducing the impact of process safety incidents.
- Human reliability improvements require focus on more than technology;
- Address the influence of
  - Culture,
  - Organization,
  - Work place,
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# Thank You!

## Questions and/or Comments?

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more information including membership

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# ASM Abstract

- In recent years, many organizations have been striving to improve process safety management performance. One aspect of improving process safety performance is to reduce the probability of human error.
- The challenges associated with human side of process safety have been a focus of the Abnormal Situation Management® (ASM) Consortium for the past fifteen years.
- The mission of the ASM Consortium, a group of 13 companies and universities in the process control industry, is to enable operating teams to proactively manage their plants to maximize safety and minimize environmental impact while allowing the processes to be pushed to their optimal limits.
- This paper presents findings on sources of operational failures and a solution framework developed to address the challenges to human reliability. The solution framework consists of seven operation practice areas that influence the effectiveness of abnormal situation management and the likelihood of process safety incidents.
- The ability of a plant to effectively prevent and respond to abnormal situations is a key element to reducing the impact of process safety incidents.
- Since 1994, the ASM Consortium has been striving to improve ASM practices through their active Research & Development program.