Accident case – BP Texas City refinery

MEC-E3004 Safety management in complex sociotechnical systems

Teemu Reiman

MEC-E3004 Safety management in complex sociotechnical systems

- Course consists of:
  - Lectures and course material
  - Learning logs after each lecture
  - Mid-term assignment (accident case)
  - Final paper on a selected topic
- Course lecturer: PhD (Psych.), Teemu Reiman (reimanteemu@gmail.com)
- Course assistant is Douglas Owen (douglas.owen@aalto.fi)

- Course material and all accouncements can be found in MyCourses

MEC-E3004 Safety management in complex sociotechnical systems
Tentative agenda and topics of the lectures

1. 2.3. Introduction and the basic concepts of safety management
2. 9.3 Basic concepts: Human Factors and Safety Management (Douglas Owen)
3. 16.3 Accident models
4. **23.3 Accident case (BP Texas City refinery explosion in 2005)**
   - Mid-term assignment
5. 30.3 Organizational learning

6.4 NO LECTURE

13.4 Returning the mid-term assignment

6. 13.4. Safety culture
7. 20.4. Safety leadership
8. 27.4. The basic principles of safety management
9. 4.5 Safety management systems
10. 11.5. Tools of safety management
11. 17.5 Future challenges and new directions of safety management (TIME!)
12. 25.5 Recap and Q&A
    - Deadline for returning the paper 31.5.2023

Application of the models depends on both context and nature of accident

Underwood & Waterson 2013

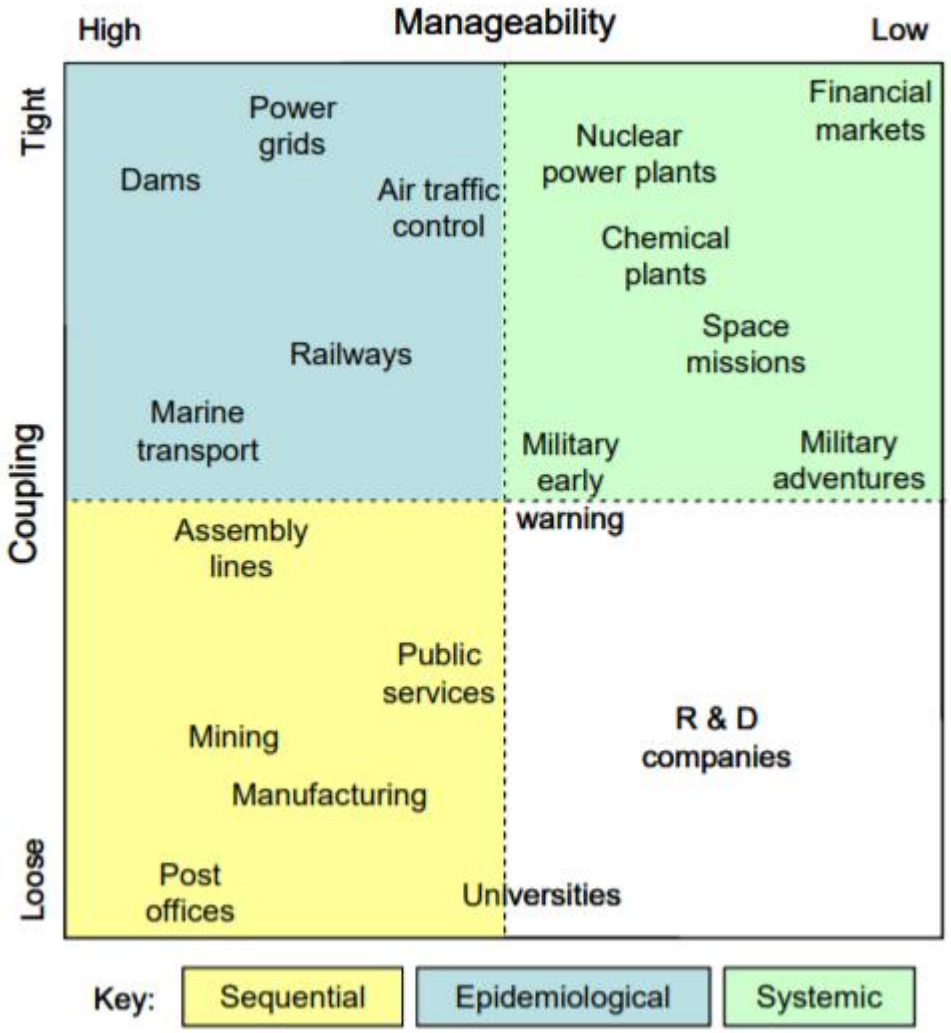
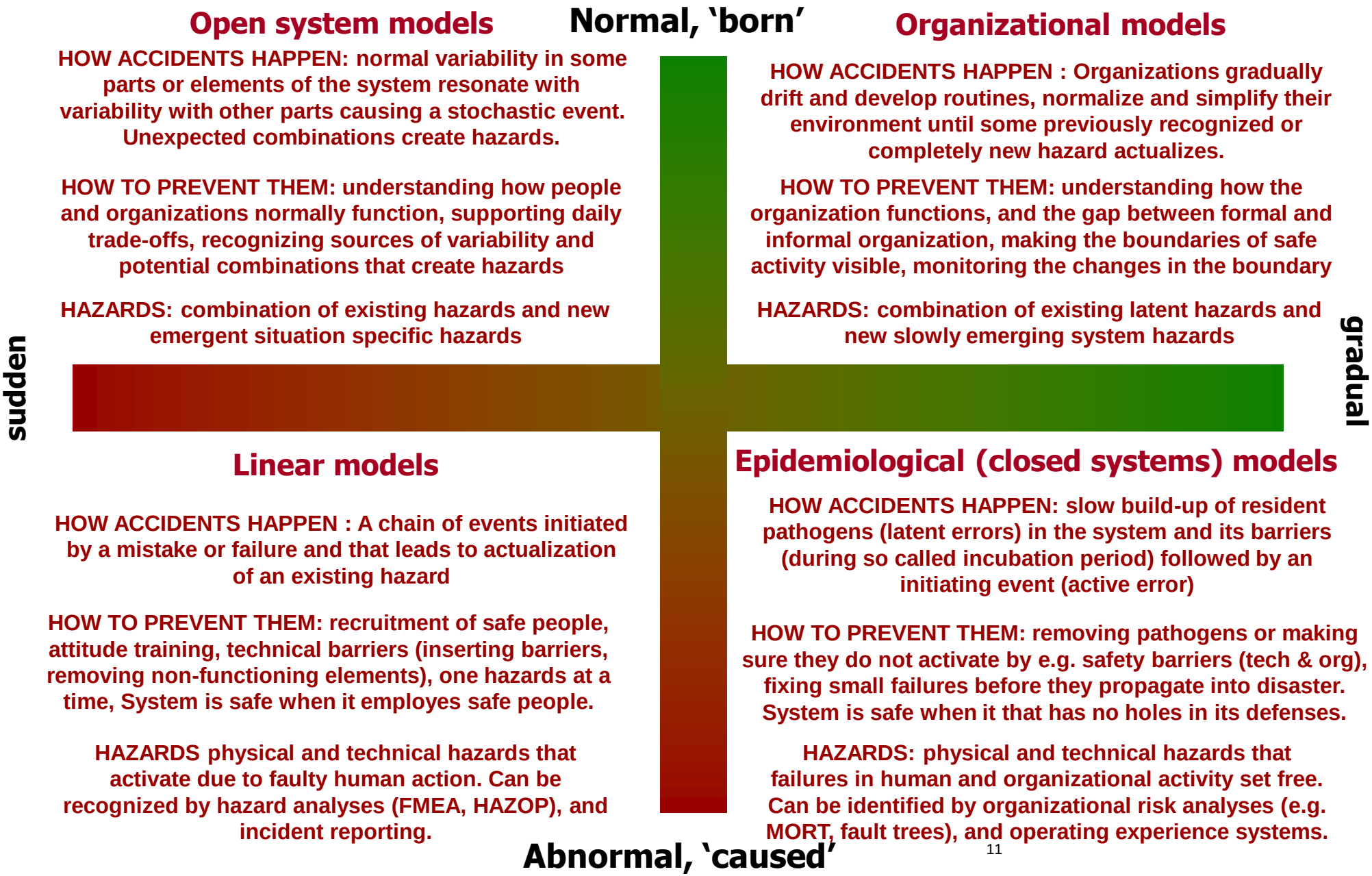


Figure 2 - Analysis technique suitability (adapted from Hollnagel (2008))

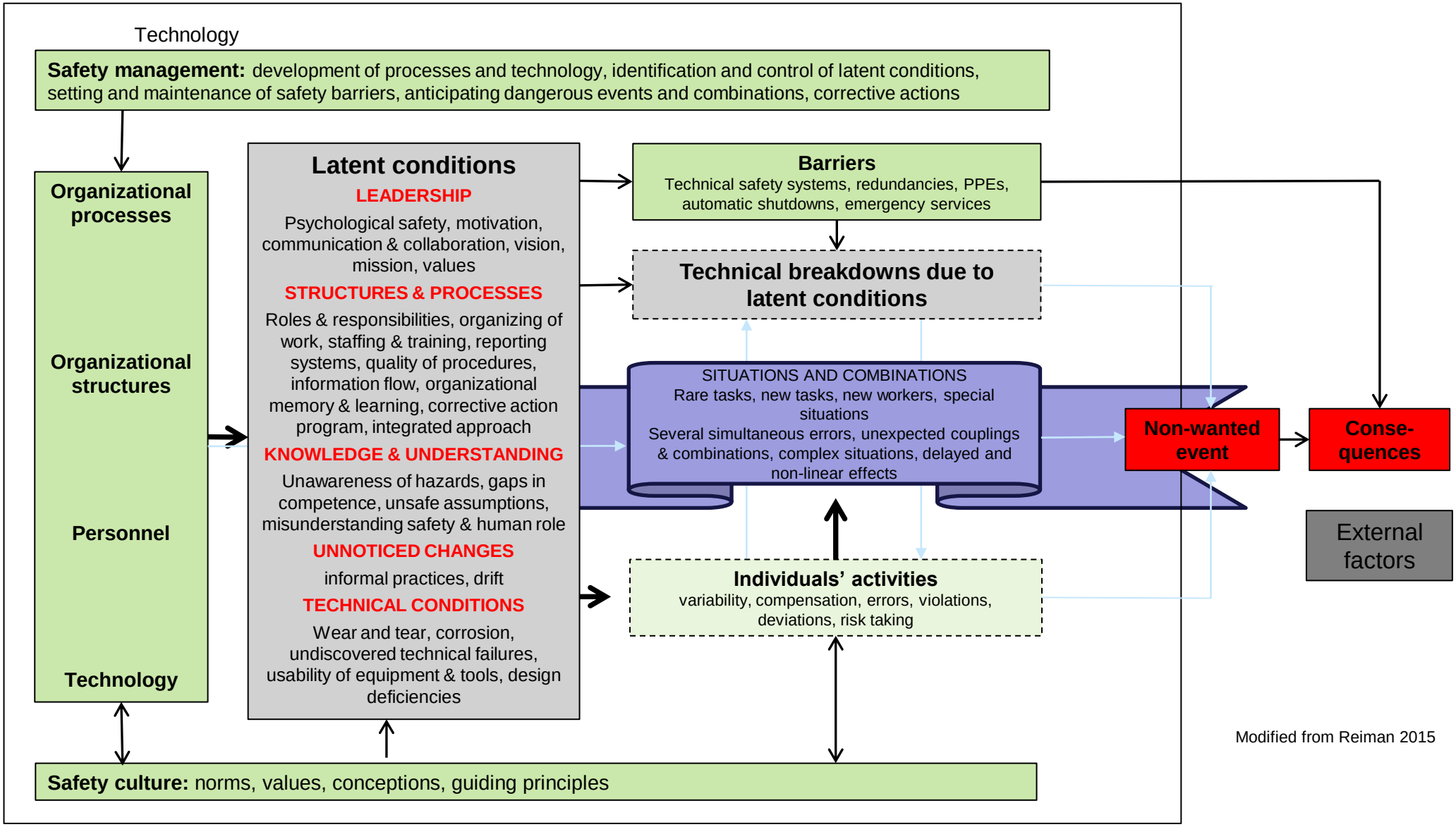
Common characteristics of major accidents

- They rarely have a single cause, a single clear mishap or malfunction as a source
  - On the other hand, ordinary mistakes can do extraordinary damage in complex technological systems
  - Typically adverse conditions develop over time, during so called incubation period
  - During this period there are weak signals that if spotted and investigated could prevent the accident
  - Typically these weak signals are neglected due to either normalizing them, or considering them in isolation as non-significant
  - Thus, most accidents are unexpected but not sudden

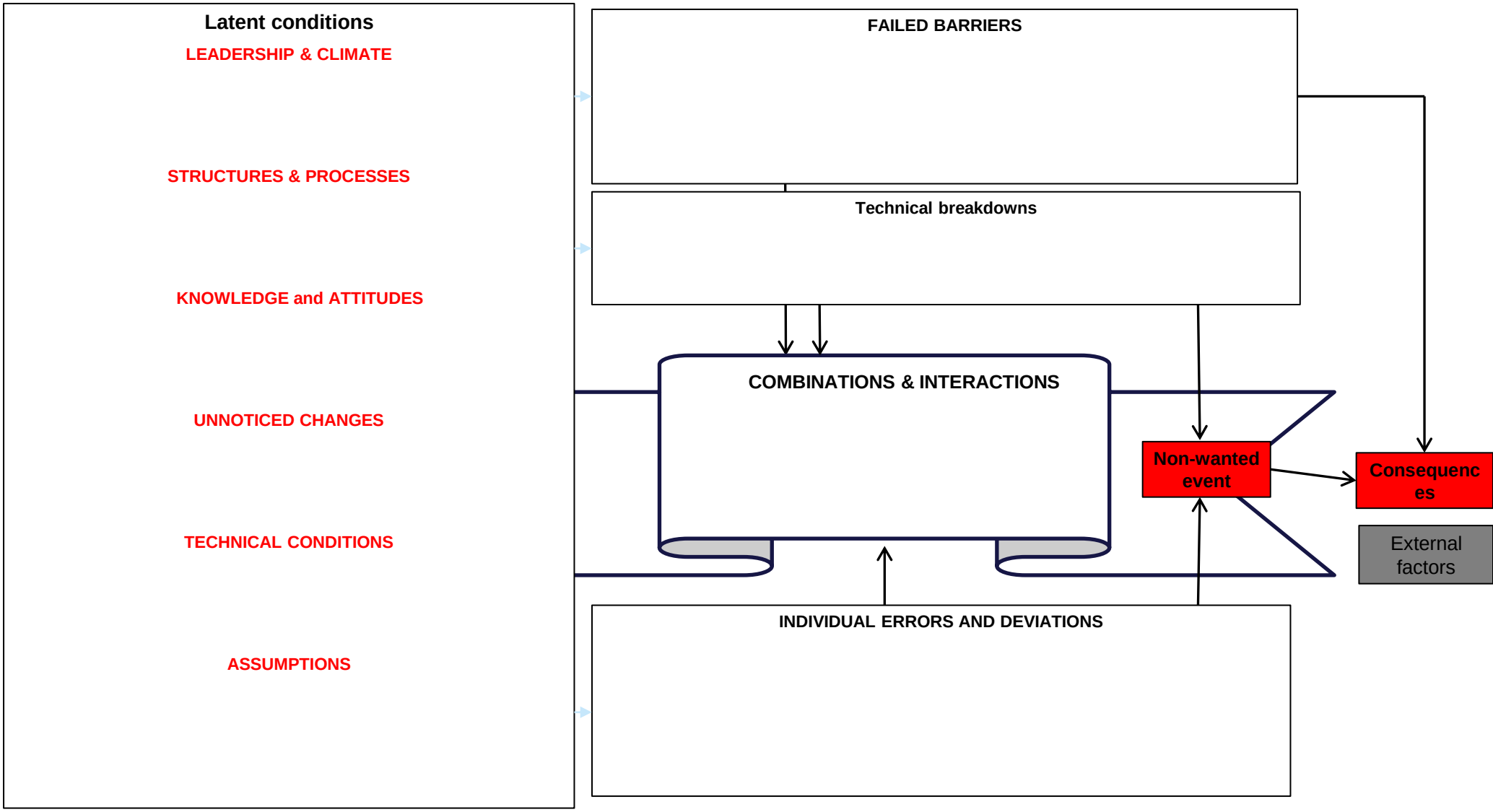
- Accidents are rarely caused by a single exceptional event but rather they are a consequence of an *unexpected combination of several ordinary events*


Normal, 'born'
Abnormal, 'caused'
sudden
gradual
Open system models
HOW ACCIDENTS HAPPEN: normal variability in some parts or elements of the system resonate with variability with other parts causing a stochastic event. Unexpected combinations create hazards.
HOW TO PREVENT THEM: understanding how people and organizations normally function, supporting daily trade-offs, recognizing sources of variability and potential combinations that create hazards
HAZARDS: combination of existing hazards and new emergent situation specific hazards
Organizational models
HOW ACCIDENTS HAPPEN : Organizations gradually drift and develop routines, normalize and simplify their environment until some previously recognized or completely new hazard actualizes.
HOW TO PREVENT THEM: understanding how the organization functions, and the gap between formal and informal organization, making the boundaries of safe activity visible, monitoring the changes in the boundary
HAZARDS: combination of existing latent hazards and new slowly emerging system hazards
Linear models
HOW ACCIDENTS HAPPEN : A chain of events initiated by a mistake or failure and that leads to actualization of an existing hazard
HOW TO PREVENT THEM: recruitment of safe people, attitude training, technical barriers (inserting barriers, removing non-functioning elements), one hazards at a time, System is safe when it employes safe people.
HAZARDS physical and technical hazards that activate due to faulty human action. Can be recognized by hazard analyses (FMEA, HAZOP), and incident reporting.
Epidemiological (closed systems) models
HOW ACCIDENTS HAPPEN: slow build-up of resident pathogens (latent errors) in the system and its barriers (during so called incubation period) followed by an initiating event (active error)
HOW TO PREVENT THEM: removing pathogens or making sure they do not activate by e.g. safety barriers (tech & org), fixing small failures before they propagate into disaster. System is safe when it that has no holes in its defenses.
HAZARDS: physical and technical hazards that failures in human and organizational activity set free. Can be identified by organizational risk analyses (e.g. MORT, fault trees), and operating experience systems.

A simplified accident model illustrating how incidents are born out of a combination of latent conditions, active variability and errors and various concurrent events.



Modified from Reiman 2015

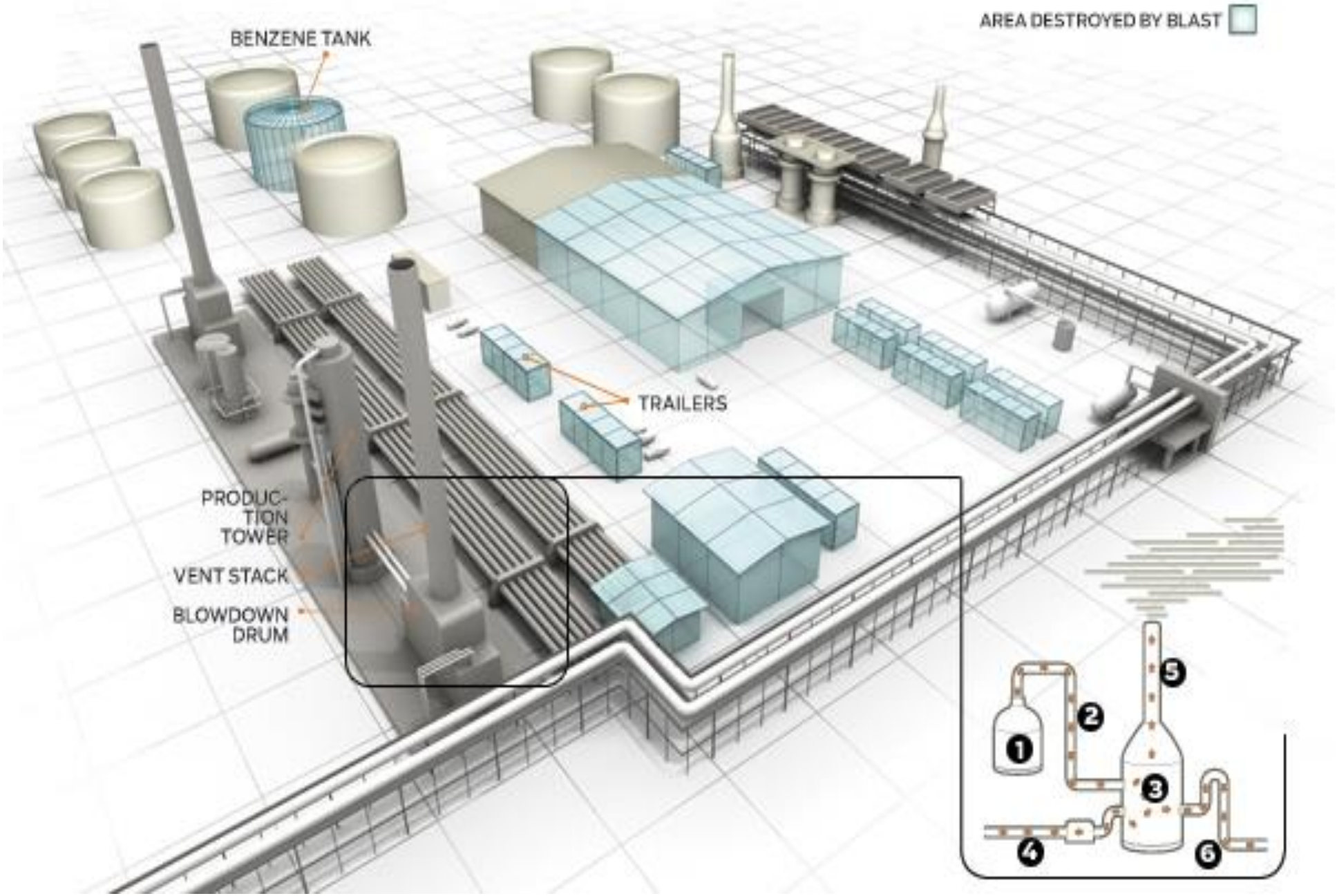

Latent conditions
LEADERSHIP & CLIMATE
STRUCTURES & PROCESSES
KNOWLEDGE and ATTITUDES
UNNOTICED CHANGES
TECHNICAL CONDITIONS
ASSUMPTIONS
FAILED BARRIERS
Technical breakdowns
COMBINATIONS & INTERACTIONS
INDIVIDUAL ERRORS AND DEVIATIONS
Non-wanted event
Consequences
External factors

BP Texas City refinery explosion 2005

- BP's Texas City oil refinery was the third largest oil refinery in the US.
- BP acquired the refinery as part of its merger with Amoco in 1999.
- The refinery was originally built in 1934
- In 23 March 2005 a massive explosion at the refinery killed 15 people and injured nearly 200.
- The isomerization unit is used to boost the octane level of gasoline – it rearranges the structure of molecules to turn naphtha into high-octane gasoline
- The isomerization unit was being started after a maintenance outage and petrol was led into the raffinate splitter (distillation column / production tower)

Raffinate splitter, after the accident

Picture: Houston Chronicle


AREA DESTROYED BY BLAST
BENZENE TANK
TRAILERS
PRODUC-
TION
TOWER
VENT STACK
BLOWDOWN
DRUM
1
2
3
4
5
6

CASE: Texas City 2005 –video (21.3min-39.3min)

https://www.youtube.com/watch?v=tq0xcM0m8aU

Group work

- Gather into groups of 4-6 people
- Discuss the explosion in light of the given accident model
  - **What kind of latent conditions can you identify?**
  - **What technical breakdowns were caused by the latent conditions?**
  - **What individual activities contributed to the event?**
  - **What circumstances coincided?**
  - **How did the safety barriers affect the event?**
- After identifying the contributing factors, consider
  - How could better safety management have prevented the accident?
  - How could better safety culture have prevented the accident?

There are several investigations of the accident

BP

FATAL ACCIDENT INVESTIGATION REPORT

FATAL ACCIDENT INVESTIGATION REPORT

Isomerization Unit Explosion
Final Report

Texas City, Texas, USA

Date of Incident: March 23, 2005
Date of Report: December 9th 2005

Approved for release by J. Mogford, Investigation team leader

CSB

U.S. CHEMICAL SAFETY AND HAZARD INVESTIGATION BOARD

INVESTIGATION REPORT

REFINERY EXPLOSION AND FIRE

(15 Killed, 180 Injured)

KEY ISSUES:
SAFETY CULTURE
REGULATORY OVERSIGHT
PROCESS SAFETY METRICS
HUMAN FACTORS

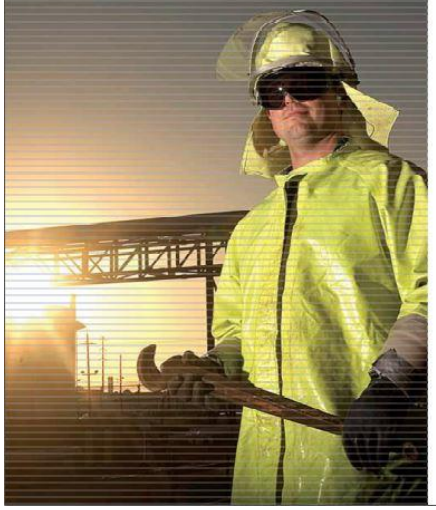
BP
TEXAS CITY, TEXAS
MARCH 23, 2005

REPORT NO. 2005-04-I-TX
MARCH 2007

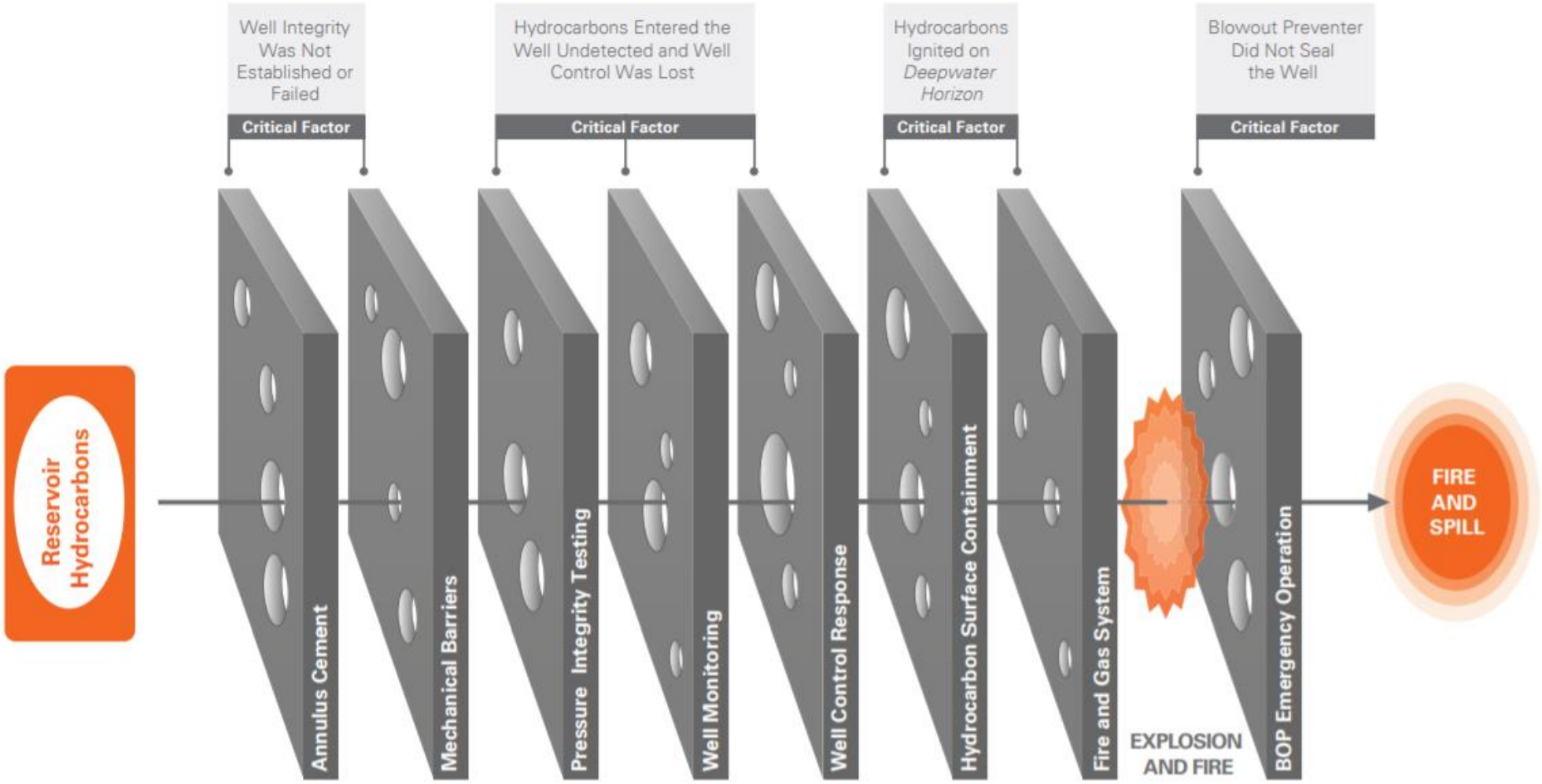
The Baker panel

JANUARY 2007

THE REPORT OF
THE BP U.S. REFINERIES INDEPENDENT SAFETY REVIEW PANEL



BP's investigation identifies which barriers were breached, but does not explain why it happened (partly because of the accident model that was used)



Adapted from James Reason (Hampshire: Ashgate Publishing Limited, 1997).

Figure 1. Barriers Breached and the Relationship of Barriers to the Critical Factors.

Mid-term assignment

- Read the paper “Space Shuttle Challenger Explosion” in MyCourses

- Answer the following questions (2-6 pages total):

1) In your opinion, what were the most significant reasons and contributing factors of the explosion of Space Shuttle Challenger?
2) In your opinion, what was the major missed opportunity to prevent the disastrous chain of events? Why was it missed?
3) What information you felt was missing from the paper that would have helped you to better understand the causes of the accident? On what topic you would have wanted more information as an accident investigator?
4) What is the relevance of the accident of the 80s for the present day safety management?

Deliver the paper before 13.4. in MyCourses

The paper is not graded but its quality affects the overall course grading

The paper can be written in English or Finnish

References

- Baker et al. (2007). The B.P. U.S. Refineries Independent Safety Review Panel. January 2007.
- BP. 2010. Deep Water Horizon Accident Investigation report.
- CSB (2007). BP Texas City. Final Investigation Report. U.S. Chemical Safety and Hazard Investigation Board. REPORT NO. 2005-04-I-TX.
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- Mogford, J. (2005). Fatal Accident Investigation Report. Isomerization Unit Explosion Final Report. Texas City, Texas, USA
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