



Lessons To Be Learned From BP Deepwater Horizon

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- Hydrocarbons escaped from the Macondo well into Transocean's *Deepwater Horizon*, resulting in fire and multiple explosions
 - 11 people were killed
 - The multi-billion dollar *Deepwater Horizon* sank
 - 4.1M gallons of hydrocarbons flowed from the well for 87 days
 - BP established a \$28B reserve to pay for damages



Causal Factors Identified by BP

1. The annulus cement barrier did not isolate the hydrocarbons
2. The shoe track barriers did not isolate the hydrocarbons
3. The negative-pressure test was accepted although well integrity had not been established



Causal Factors Identified by BP

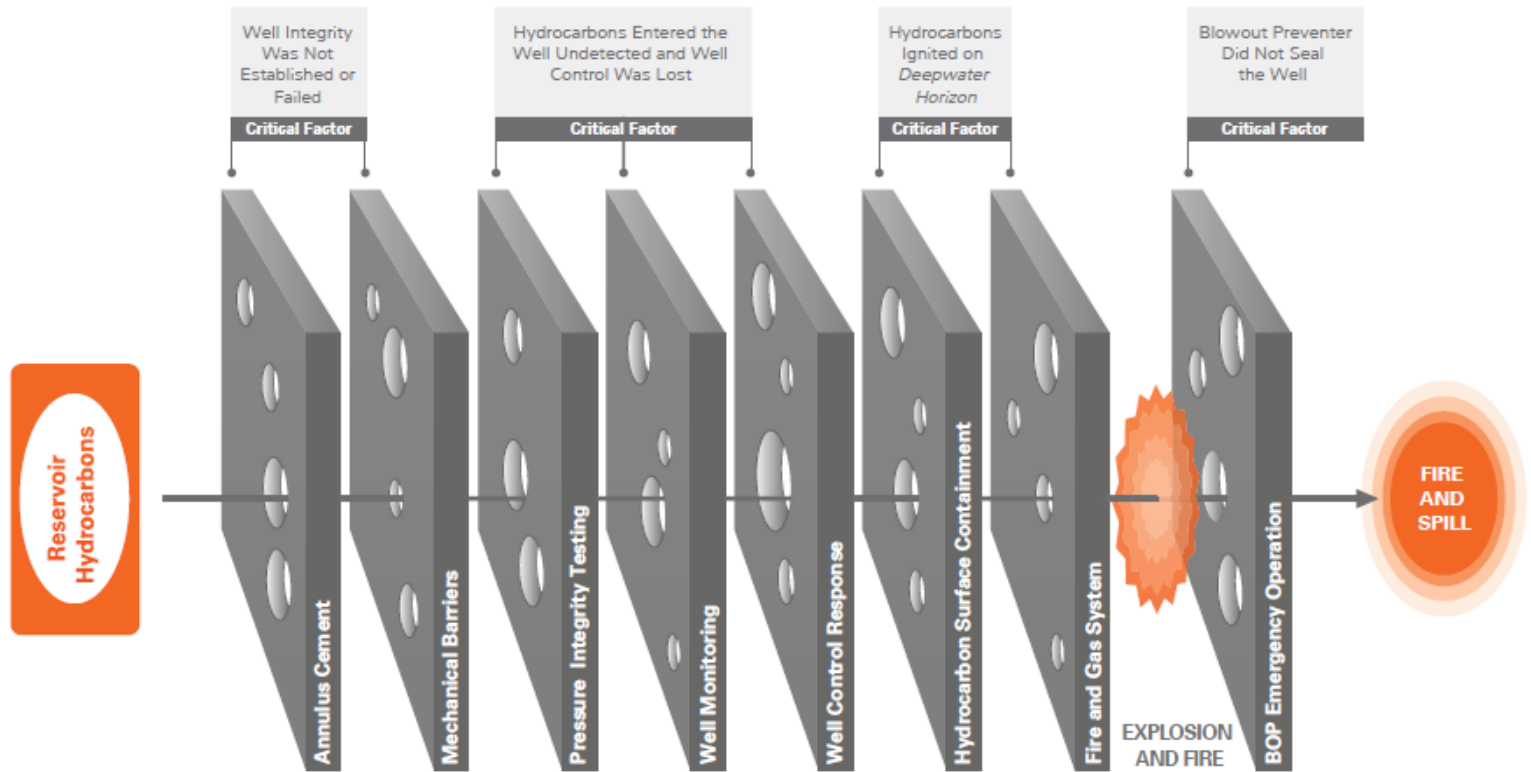
4. Influx was not recognized until hydrocarbons were in the water
5. Well control response failed to regain control of the well
6. Diversion to the mud gas separator resulted in gas venting onto the rig



Causal Factors Identified by BP

7. The fire and gas system did not prevent hydrocarbon ignition
8. The BOP emergency mode did not seal the well

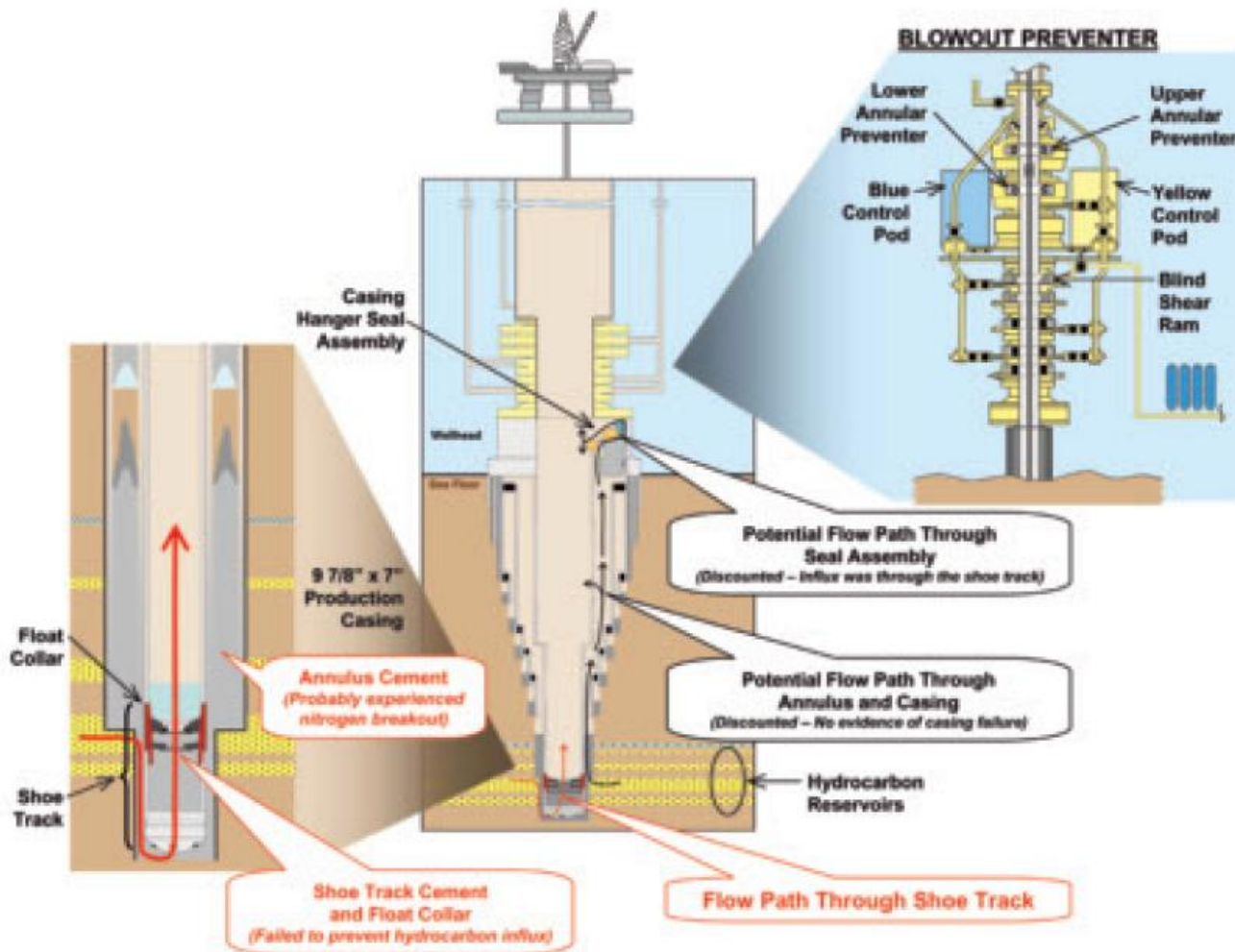
Causal Factors Identified by BP



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

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

The Macondo Well



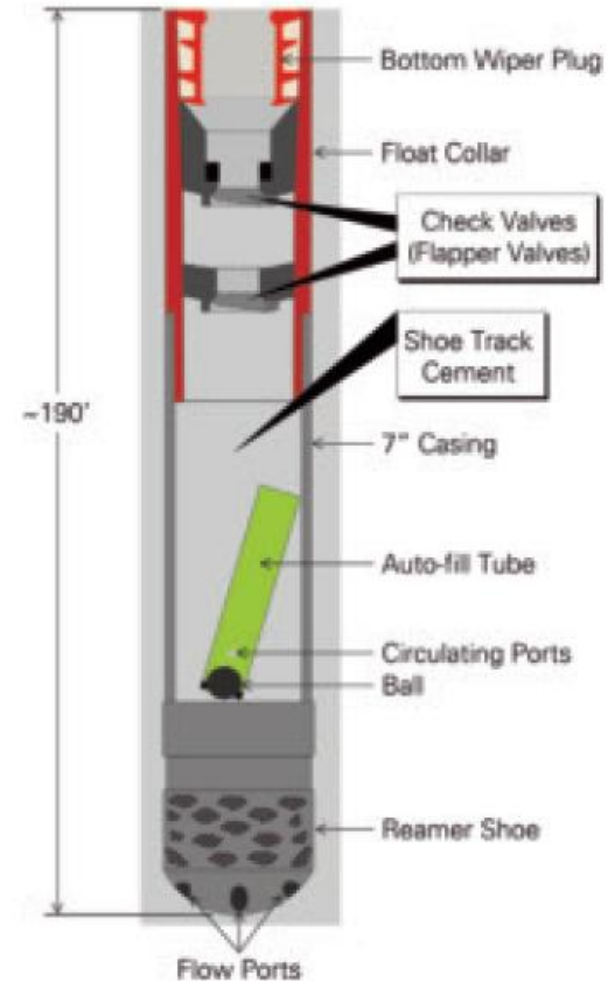


Annulus Cement Failure

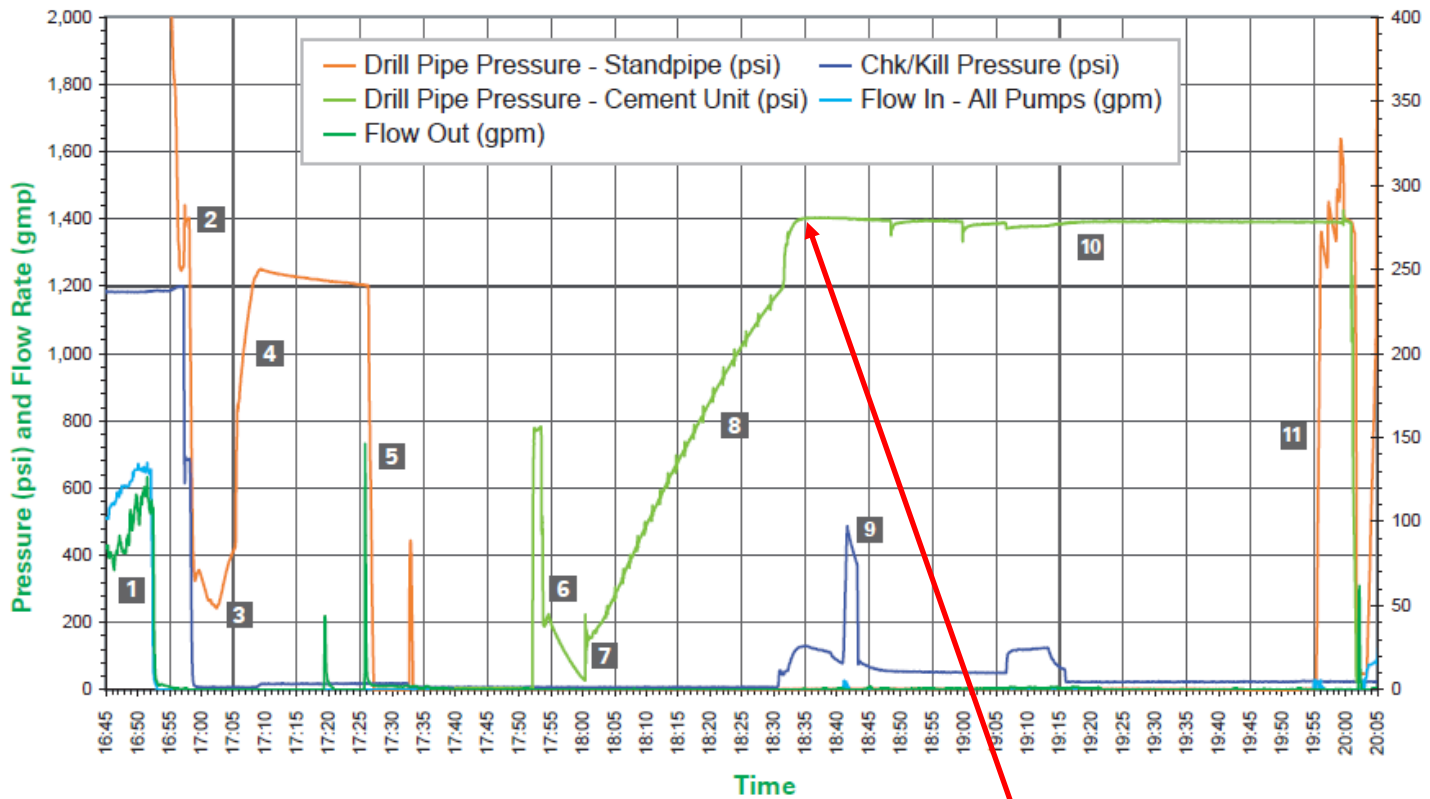
- This was the primary physical barrier
- Cement had been poured the previous day into the wellbore annulus in preparation for moving the rig
- Weaknesses were noted in cement design and testing, QA, and risk assessment

Shoe Track Barrier Failure

- Both the shoe track cement and the float collar failed to allow hydrocarbons up the wellbore
- Potential common mode failure with failure of the annulus cement barrier



Negative Pressure Test Interpretation



Critical interpretation anomaly

Influx Not Recognized

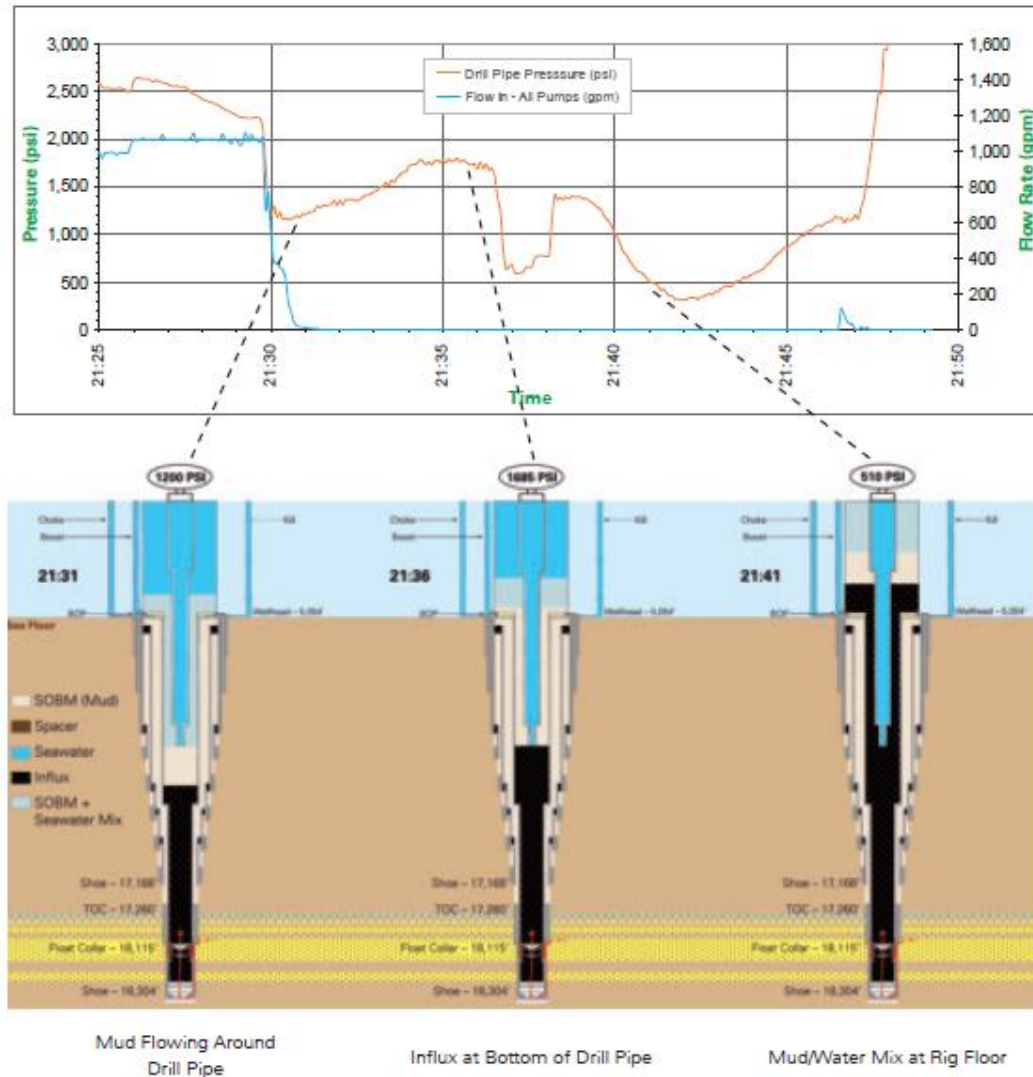


Figure 16. Modeled Pressure Responses Resulting from Hydrostatic Changes in the Wellbore.

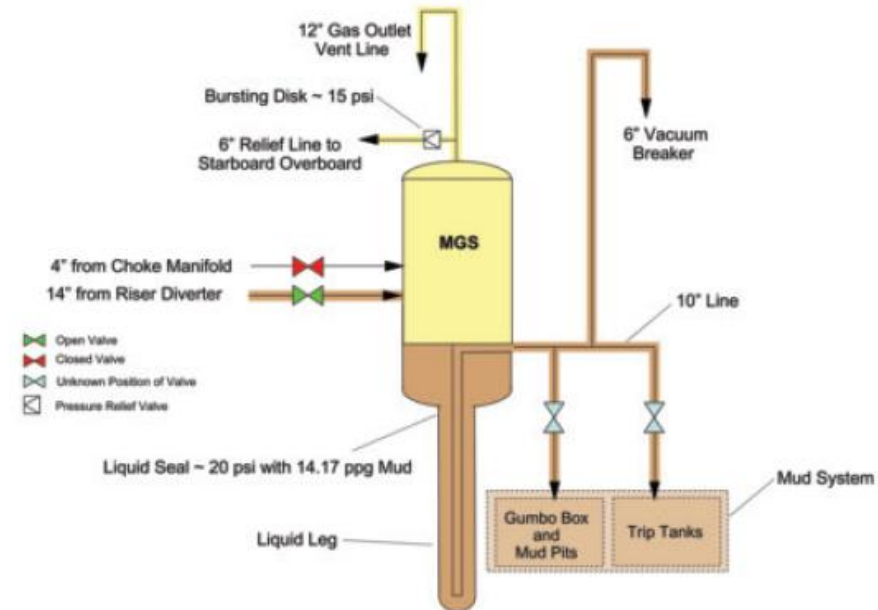


Well Control Response Actions

- Crew shut the BOP and diverter, routing fluids exiting the riser to the mud gas separator (MGS)
- Volume of hydrocarbons overwhelmed MGS sending hydrocarbons into the rig
- Diverting overboard would have delayed the explosion

Mud Gas Separator Design

- From the MGS hydrocarbons vented directly into the rig through a 12 inch goosenecked vent
- This design feature was not understood by the operators



Fire and Gas system Design

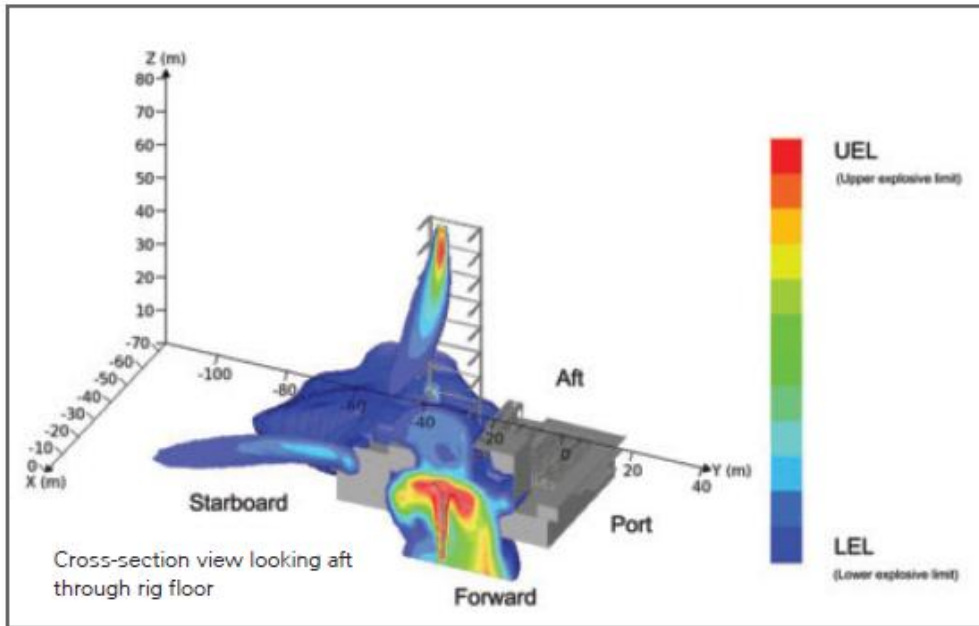


Figure 10. Vapor Dispersion at 240 Seconds.

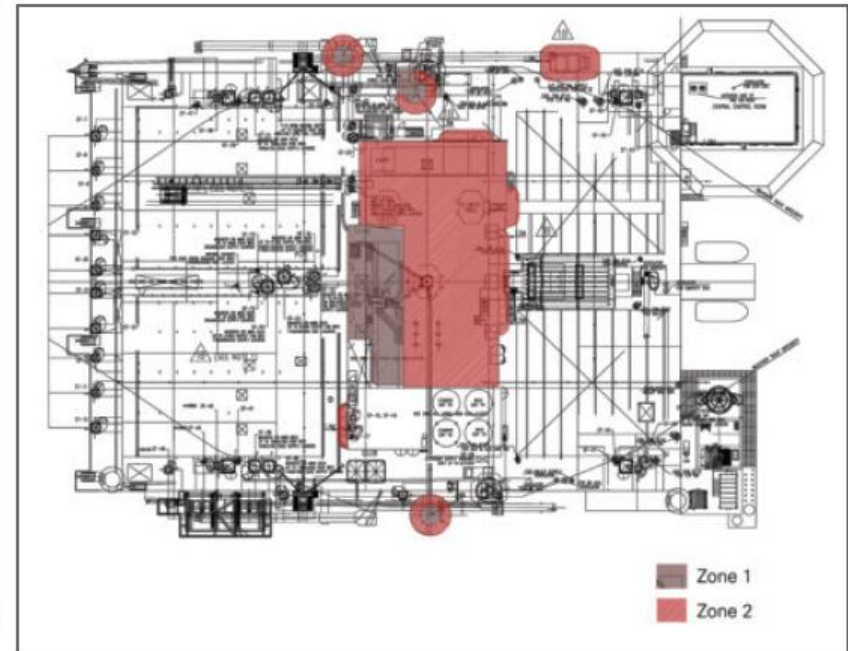


Figure 17. Hazardous Area Classification—Main Deck.



BOP Emergency Mode Failure

- Likely due to interruption of MUX signal by explosions
- Yellow and Blue control pods likely were not operable at the time of the event
- Actions by remotely piloted vehicles to shut the BOP likely initiated autoshear function, but did not seal the well



BP Investigation Recommendations

1. Strengthen procedures and engineering practices
2. Improve technical and operational capability and competency
3. Strengthen audit and verification practices
4. Improve Process Safety Performance Management



BP Investigation Recommendations

5. Improve cementing services assurance
6. Improve well control practices
7. Improve rig process safety through better HAZOP performance
8. Improve BOP design and assurance



What's Missing?

- This is a Newtonian perspective of the failures leading to the event
 - Linear, not complex adaptive
- Did not take into account the previous findings of the Chemical Safety Board (CSB) on the Texas City refinery fire and explosion



CSB Texas City

Recommendations for BP BOD

- 2005-4-I-TX-R11. Appoint an additional non-executive member of the Board of Directors (BOD) with specific expertise in refinery operations and experience and process safety. Appoint this person to be a member of the Board Ethics and Environmental Assurance Committee
 - Status: **Not implemented**



CSB Texas City Recommendations for BP BOD

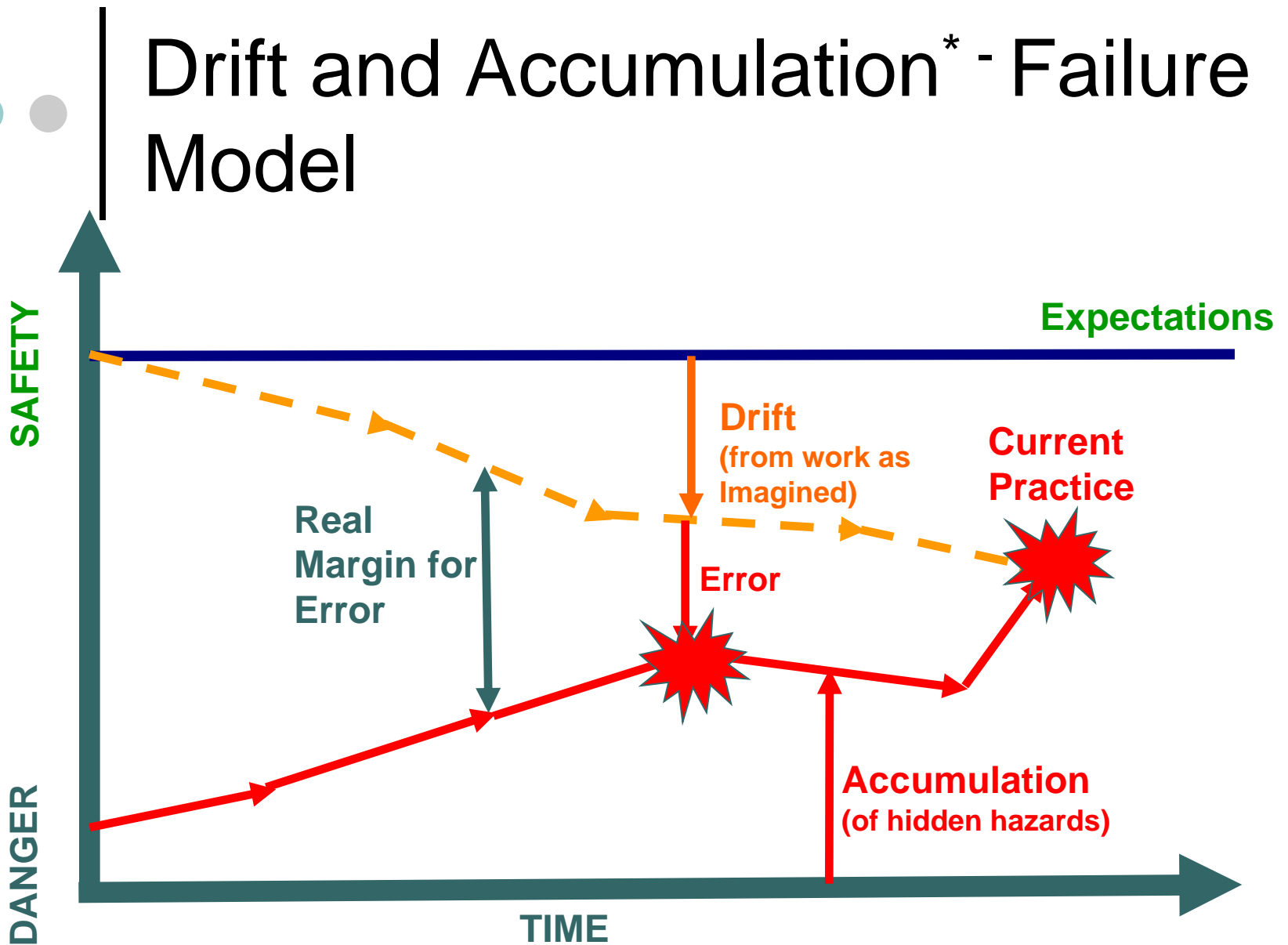
- 2005-4-I-TX-R12. Ensure and monitor that senior executives implement an incident reporting program throughout BP's refinery organization
 - Status: **Not implemented**



CSB Texas City Recommendations for BP BOD

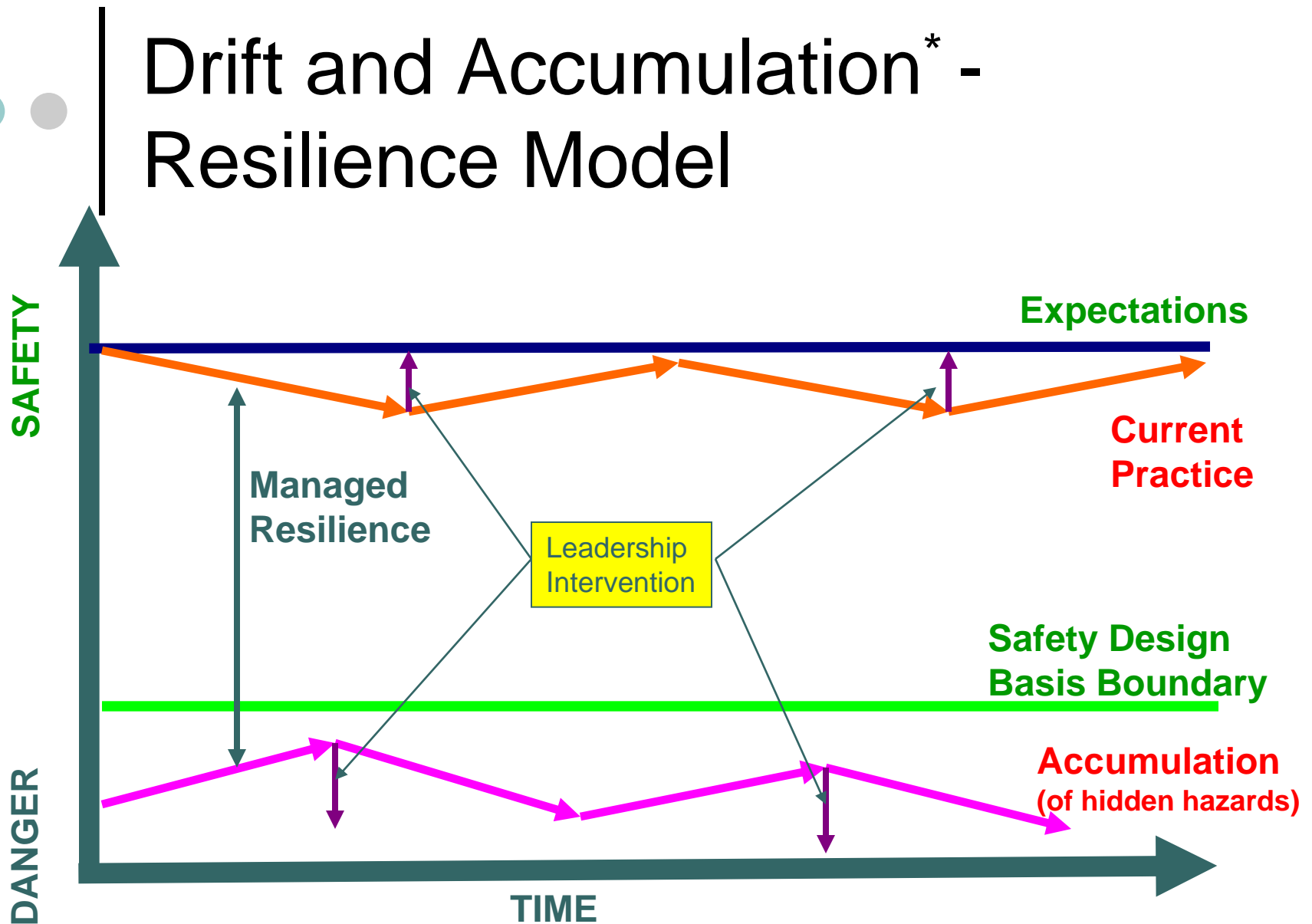
- 2005-4-I-TX-R13. Ensure and monitor that senior executives use leading and lagging process safety indicators to measure and strengthen safety performance in BP refineries
 - Status: **Not implemented**

Drift and Accumulation* - Failure Model




* Adapted by Muschara Error Management Consulting, LLC. Used with permission.

Drift and Accumulation* - Resilience Model

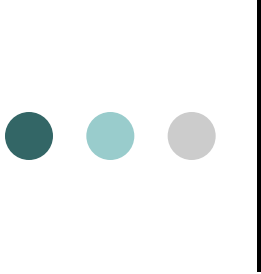


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Lessons to be learned from BP *Deepwater Horizon*

- This was an organizational failure originating with the BP BOD in London
- Despite loss of over \$28B, BP returned to profitability within 2 quarters
- Absent a strong profit incentive, BP's BOD is unlikely to change its culture



Lessons to be learned on culture change

- From Schein: Culture is broad, deep and steady
 - “ The only thing of real importance that leaders do is to create and manage culture...”
- Before setting out to change culture, managers must decide if the view will be worth the climb



Questions?