

Eye Opener Analysis of the Macondo Blowout

Turning Safety Requirements into Operational Practice

Here we present a “forensic” application of [Eye Opener](#) to the [2010 Macondo oil spill](#), a benchmark case in offshore engineering failures. The analysis identifies practical steps not stated in the [Commission’s Report](#) and outlines a path toward self-regulating operations. The core novelty lies in treating rule violations not as mere failures, but as potential sources of stability, based on the dialectical principle that synthesis emerges from complementarity rather than suppression.

Case Description.

After drilling to target depth, the crew attempted to temporarily abandon the well by installing a cement barrier. The nitrogen-foamed cement failed to provide effective isolation, allowing hydrocarbons to enter the wellbore. Critical warning signs, including anomalous pressure test results, were misinterpreted, and operations continued. The resulting blowout bypassed the Blowout Preventer (BOP), leading to an explosion that killed 11 workers and caused the largest marine oil spill in history.

Turning Recommendations into Actionable Steps

We uploaded the [380-page Commission report](#) into ChatGPT (OpenAI, GPT-5.3) to identify the four key recommendations for the drilling company. The exact prompt and output are provided in the [Supplementary Material](#) (SM). These recommendations were then analyzed using [Eye Opener](#) (v. 6.1.1, based on Claude Sonnet 4.5) as independent theses (Table 1).

Table 1. Starting theses and antitheses

Uploaded Theses	Antitheses (suggested by Eye Opener)
T1 = No negative pressure test = no displacement	A1 = Displacement permitted despite test anomalies
T2 = Cement integrity must be independently verified before proceeding	A2 = Proceed based on operator’s internal assessment
T3 = Blowout preventer (BOP) must meet verified functional redundancy standards	A3 = Relay on single-layer protection without verification
T4 = Formal stop-work authority with mandatory escalation protocol	A4 = No stop-work authority

Alongside, we provided the case description as contextual input. Each thesis (T) was paired with an antithesis (A) representing rule violations; both were assigned upsides and downsides (using the [Generative Rules](#)) and arranged into causal sequences, as shown in Fig. 1.

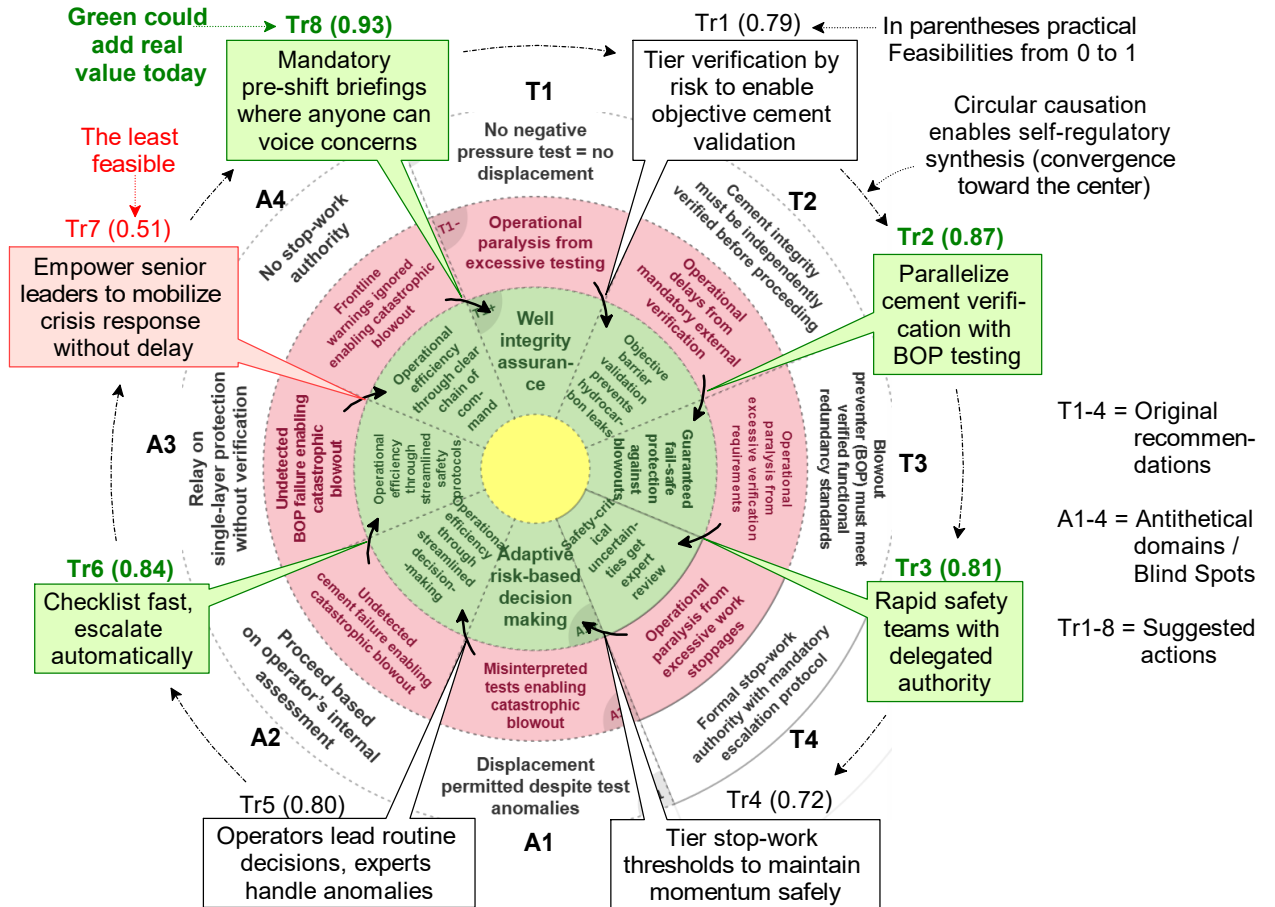


Fig. 1. Dialectical wheel with transition steps (“Action Plan”).

The wheel consists of eight segments: four representing the original theses (Commission recommendations) and four representing their antitheses, which capture implicit blind spots and are positioned diagonally opposite their corresponding theses. The outer (red) layer indicates risks (downsides), while the inner (green) layer indicates benefits (upsides). Downsides of each segment are transformed into upsides of the next segment through transition steps (Tr1–Tr8), creating a spiral convergence toward the center, where synthesis occurs.

Each transition step (Tr) is assigned a feasibility score (F). The prompt and example Tr outputs are provided in [SM-2](#). Feasibility estimates were obtained using ChatGPT (OpenAI, GPT-5.3).

Practical Implications

Among all transition steps, those highlighted in green satisfy three criteria: high feasibility, absence from the Commission’s report, and strong practical relevance (see [SM-3](#)).

Table 2. Actionable additions to existing recommendations.

Suggested Tr step	Novelty and Use
Tr8 (0.93) — mandatory pre-shift briefings where anyone can raise concerns	The Commission did call for whistleblower protection, but a formal pre-shift speak-up checkpoint before high-risk work is a more concrete operational mechanism. People may have stop-work authority on paper, yet concerns still get muted in operations.
Tr3 (0.81) — rapid safety teams with delegated authority	The report emphasized stronger safety systems and accountability, but not a small multidisciplinary team with delegated go/no-go authority during critical phases. That could help today by reducing the gap between formal rules and real-time decision quality.
Tr6 (0.84) — checklist fast, escalate automatically	The Commission focused on barrier validation and decision failures, but not on a standardized rapid field checklist tied to automatic expert escalation. That could reduce reliance on memory, hierarchy, and improvisation.
Tr2 (0.87) — parallelize cement verification with BOP testing	The report cared deeply about cement, BOP reliability, and response capability, but not about workflow design to remove unnecessary sequencing delays. This could help to preserve safety without turning verification into a scheduling bottleneck.

These results suggest specific improvements to current practice:

- (1) introduce pre-shift speak-up checkpoints;
- (2) use rapid safety teams for real-time decisions;
- (3) implement checklists with automatic escalation;
- (4) remove verification bottlenecks through parallel workflows.

Crisis Governance

Transition [Tr7](#) (highlighted in Fig. 1) addresses a critical weakness in offshore operations: how to act during an actual blowout. The initial formulation—enabling senior management to mobilize crisis response—may be perceived by regulators as bypassing established protocols, and was therefore assigned low feasibility.

To resolve this, Tr7 was re-analyzed independently as a new thesis (T5) using Eye Opener (Fig. 2). This allowed decomposition into two components:

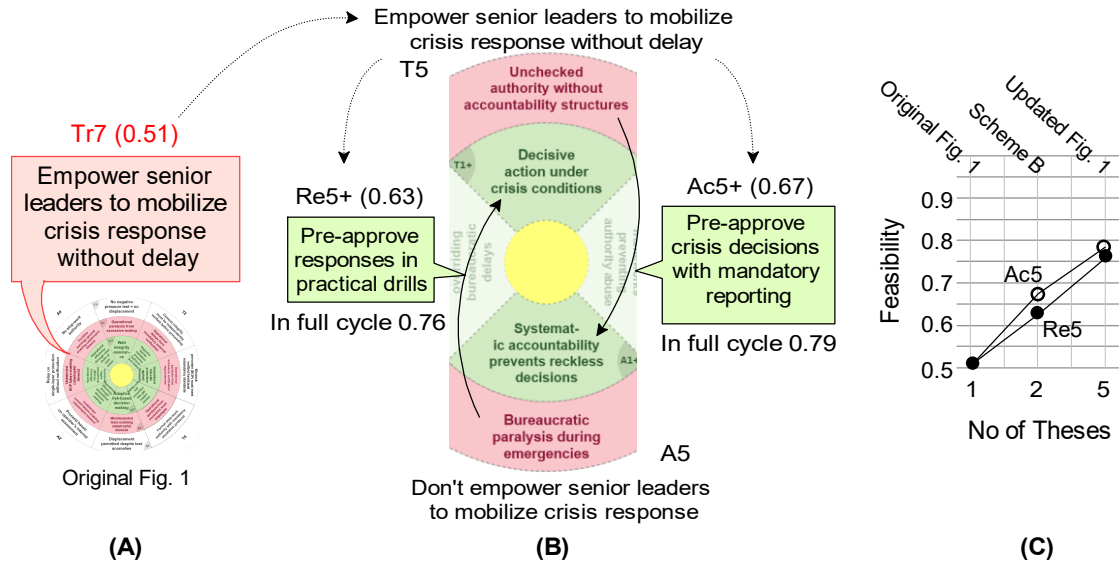


Fig. 2

- **Ac5**: rapid action with real-time documentation and accountability;
- **Re5**: predefined actions supported by training and drill programs.

This reframing preserves rapid response capability while embedding accountability and preparedness, thereby removing regulatory concerns. As a result, feasibility increases from 0.51 to 0.77 ± 0.2 (Scheme C).

The improvement is achieved by (1) establishing standardized response routines through drills, and (2) integrating these routines into the overall system (Fig. 1). Ac5 and Re5 can therefore be added to Table 2 as additional steps that strengthen operational readiness, while not being explicitly stated in the original report.

Cooperative Effects

How does the feasibility of individual steps depend on their combination? To examine this, we evaluated the feasibility of a single recommendation (T1) when implemented alone (Fig. 3A), and then progressively combined it with additional recommendations in two-, three-, and four-thesis setups (Fig. 3B–C and Fig. 1).

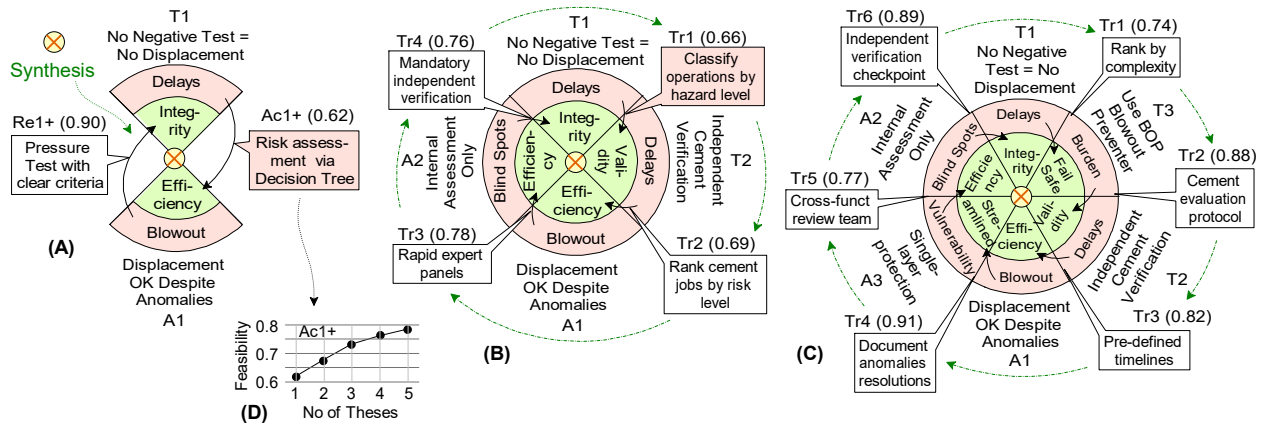


Fig. 3

Feasibility estimates for the corresponding transition ($Ac1^+$) were obtained for each configuration (see [SM-4](#)). The results (Fig. 3D) show that feasibility increases from 0.62 in the single-thesis case to 0.73 in the three-thesis setup, and further to 0.78 in the full combined system (Figs. 1–2), with diminishing incremental gains.

This indicates that individual recommendations become more effective when implemented together. The strongest improvement occurs when combining the first three recommendations (T1–T3), suggesting that early integration yields the largest benefit, while additional elements provide smaller incremental gains.

More generally, these results show that effectiveness arises from **interaction rather than accumulation**. The system operates through circular causation, where each step reinforces others, producing a convergent (self-regulating) behavior. Greater diversity of coordinated steps increases this effect.

The analysis also highlights the role of antitheses. A recommendation applied without accounting for its opposing conditions tends to generate inefficiencies (red zone). Incorporating both the rule and its counter-condition enables balanced operation and prevents such effects.

Achieving Maximum Effect

The dialectical wheel in Fig. 1 represents only one of many possible configurations; a more complete set of permutations is provided in [SM-5](#). As the number of theses increases, the number of possible transitions grows rapidly: for N theses, there are $(4N^2 - 2N)$ potential

transformations between upsides and downsides. For example, $N = 4$ yields 56 possible transitions, of which only 8 are represented in Fig. 1.

A more complete analysis would generate a broader set of such transformations—especially when using multiple AI methods (Fig. 4)—and evaluate them in terms of feasibility, novelty, and practical value.

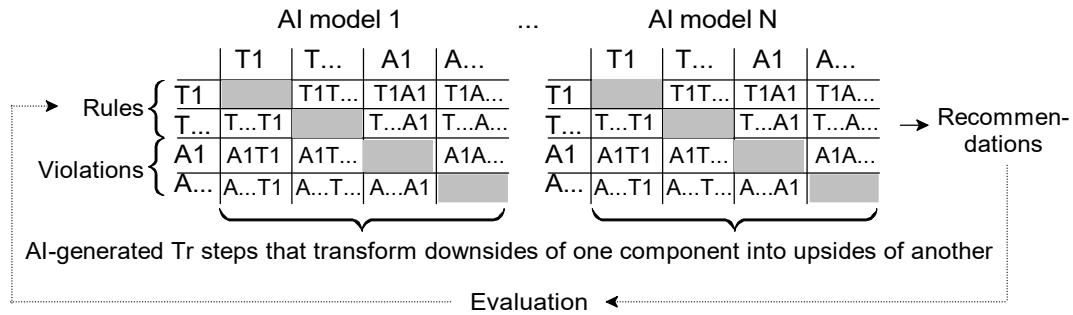


Fig. 4

The most feasible transitions can be clustered by functional similarity and contextual factors (e.g., operational conditions, decision tempo, or organizational constraints), while the least feasible decomposed into sub-steps, as illustrated in Fig. 2. In this sense, the Tr-matrix encodes the space of viable actions that enables adaptive, self-regulating behavior.

Different causal sequences of such steps prevail under different conditions, and effectiveness arises from selecting and combining them in real time.

Conclusion

This study shows how the Commission's recommendations can be converted into operational practice by explicitly incorporating their violations and interactions. The Eye Opener method enables identification of missing steps, reveals cooperative effects between recommendations, and supports construction of self-regulating operational systems. While demonstrated on the Macondo case, the approach is sufficiently general to be applied to other complex systems where formal rules must operate under real-world conditions.

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Supplementary Material.

Starting Prompt and Output

Exact prompt for extracting the top 4 recommendations for the drilling company from Commission's Report: *"Identify the top four strict, non-negotiable requirements for the drilling company, formulated as mandatory and practically controllable steps."* Output:

1. **T1 = No negative pressure test = no displacement.** Hydrocarbons must never be introduced (e.g., mud displaced with seawater) until two independently verified, clearly interpreted negative pressure tests confirm well integrity—with mandatory halt/escalation on any anomaly.

2. **T2 = Cement integrity must be independently verified before proceeding.** Critical cement barriers (especially the production casing) must undergo objective validation (e.g., cement bond log or equivalent), and operations cannot continue unless results meet predefined integrity criteria.

3. **T3 = Blowout preventer (BOP) must meet verified functional redundancy standards.** The BOP system must include tested, redundant shear capability and real-time condition verification, with no drilling allowed unless full functionality is confirmed and documented immediately prior to high-risk operations.

4. **T4 = Formal stop-work authority with mandatory escalation protocol.** Any crew member or contractor can halt operations without penalty, and any safety-critical uncertainty automatically triggers a documented escalation to senior engineering authority before work resumes

Transition steps in Fig 1

Prompt: Estimate the practical Feasibility (0 to 1) of each of the following steps (21-28) below. Assume that each step can influence other step(s) in the following combination: Ac1+ and Re1+ and Ac2+ and Re2+ and Tr21+ and Tr22+ and Tr23+ and Tr24+ and Tr25+ and Tr26+ and Tr27+ and Tr28+ belong to the same causality circle.

[Inserted are the outputs of Eye Opener-generated transition steps:

... description of Tr21 omitted ...

22) **Tr22** = Transforms T2- (Verification delays become operational bottlenecks) into T3+ (Fail-safe reliability through tested backup systems) = Parallelize verification to eliminate bottlenecks. Overlap cement verification with BOP testing during curing delays.

Establish pre-approved fast-track verification protocols for cement integrity that automatically trigger parallel preparation of BOP redundancy testing. During the cement curing period, conduct simultaneous documentation review and pre-staging of BOP verification equipment, converting what would be sequential bottlenecks into overlapping quality assurance workflows that maintain safety standards while preserving operational momentum toward fail-safe system validation.

Key Factors: Pre-existing regulatory framework, established third-party verification industry, operational timeline compatibility

Argumentation: The transition from verification bottlenecks to fail-safe reliability through parallel workflows is highly feasible in offshore drilling contexts because: (1) post-Macondo regulations (Bureau of Safety and Environmental Enforcement) already mandate both cement integrity verification and BOP testing, creating legal scaffolding for integration; (2) the cement curing period (typically 12-24 hours) provides a natural window for concurrent BOP preparation without adding operational time; (3) third-party verification companies (like Schlumberger, Halliburton) already possess equipment and protocols for both cement evaluation and BOP testing; (4) the oil and gas industry has successfully

implemented similar parallel verification workflows in subsea well completion operations. The primary barriers are coordination complexity between contractors and initial protocol development costs, but the Bureau of Ocean Energy Management's 2016 Well Control Rule already encourages such integrated approaches, and major operators (Shell, BP, Chevron) have adopted coordinated verification schedules post-Macondo.

Conditions for Success: Standardized inter-contractor communication protocols, pre-negotiated verification service agreements with clear scheduling provisions, digital workflow management systems that track parallel operations in real-time, and regulatory guidance documents that explicitly endorse parallel verification approaches as compliance pathways

23) **Tr23** = Transforms T3- (Verification bureaucracy paralyzes critical operations) into T4+ (Empowered safety culture prevents disasters) = Empower teams to verify and halt.

Create rapid safety teams with delegated authority to decide.

When verification and testing requirements threaten to create operational gridlock, establish a rapid-response safety review team with delegated authority to make real-time go/no-go decisions on critical operations. This team should include frontline workers, supervisors, and technical experts who can collectively assess whether safety standards are met and empower any member to halt work if concerns arise. Schedule daily briefings during high-risk phases where the team reviews upcoming operations, pre-approves certain standard procedures to reduce delays, and creates clear escalation pathways for anomalies. By converting bureaucratic verification processes into collaborative decision-making forums, the potential paralysis from over-testing transforms into an empowered safety culture where workers feel both authorized and supported to stop unsafe work while maintaining operational momentum.

Key Factors: Regulatory alignment with existing post-Macondo frameworks, availability of multi-disciplinary personnel on offshore platforms, organizational commitment to flatten decision-making hierarchies

Argumentation: The transition from verification bureaucracy to empowered safety culture through rapid-response safety teams is moderately feasible because the offshore drilling industry already has precedent for multi-disciplinary safety committees following Deepwater Horizon reforms. The Bureau of Safety and Environmental Enforcement (BSEE) post-2010 regulations explicitly encourage collaborative safety protocols and worker empowerment. Resource requirements are manageable—offshore platforms already staff diverse technical experts, and daily safety briefings are industry standard. The primary challenge lies in cultural transformation: shifting from hierarchical approval chains to delegated team authority requires management buy-in and training. Companies like Shell and BP have successfully implemented similar "bridging document" approaches where cross-functional teams pre-approve standard procedures while maintaining escalation rights. Timeline is realistic (6-12 months for full implementation) as it builds on existing infrastructure rather than creating entirely new systems. Political resistance may come from mid-level managers fearing authority dilution, but frontline worker support is typically strong, and regulatory bodies favor such approaches.

Conditions for Success: Executive-level mandate explicitly authorizing team decision-making authority, structured training programs on collaborative risk assessment for all team members, integration of team decisions into legal compliance documentation, and protection against liability for good-faith safety stops

... Tr24 and Tr24 omitted ...

26) **Tr26** = Transforms A2- (Unvalidated barriers lead to catastrophic failure) into A3+ (Streamlined operations enable rapid response) = Checklist fast, escalate automatically. Empower rapid safety checks with automatic expert escalation protocols.

When unvalidated cement barriers have failed catastrophically, immediately establish a rapid-response assessment protocol that empowers field operators to make swift preliminary safety evaluations using standardized checklists while simultaneously triggering automatic escalation to specialized technical teams. This transforms the crisis state of barrier failure into streamlined emergency operations by converting the urgency of failure into structured rapid decision-making authority, most effectively implemented immediately after incident detection when speed is critical but ad-hoc responses risk compounding errors.

Key Factors: Existing regulatory frameworks support rapid-response protocols; offshore industry has proven standardized checklist methodologies (e.g., API standards); major barrier is integrating real-time escalation systems with legacy communication infrastructure

Argumentation: The transition is moderately feasible because the offshore drilling industry already operates under strict regulatory oversight post-Macondo, with established incident command systems and standardized operating procedures. The proposal leverages existing checklist-based methodologies proven effective in aviation and medical fields, which the oil and gas sector has increasingly adopted. Resource requirements are manageable: standardized checklists can be developed within 3-6 months using existing safety protocols; field operators already possess baseline assessment skills; and automatic escalation systems can integrate with current SCADA and communication platforms. Political support is strong given regulatory emphasis on rapid incident response post-Deepwater Horizon. The primary challenge is ensuring automatic escalation triggers function reliably in remote offshore environments with potential communication failures, and overcoming organizational resistance to empowering field-level decision authority during crises. Precedent cases include successful implementation of similar protocols in nuclear power (emergency operating procedures) and aviation (Quick Reference Handbooks), though offshore drilling presents unique challenges with isolated platforms and compressed decision timeframes.

Conditions for Success: Successful implementation requires: (1) investment in redundant communication infrastructure to ensure escalation pathways remain functional during equipment failures; (2) comprehensive training programs that build field operator confidence in using standardized assessment tools under high-stress conditions; (3) organizational culture shift toward distributed decision-making authority, supported by liability protections for operators making good-faith rapid assessments; (4) regular simulation drills that test both checklist effectiveness and escalation response times; (5) regulatory clarity defining acceptable rapid-response assessment standards that balance speed with safety rigor

27) **Tr27** = Transforms A3- (Catastrophic failure when single barrier fails) into A4+ (Decisive leadership enables efficient operations) = Convert failure into decisive action. Empower senior leaders to mobilize crisis response without delay.

When a single-layer protection system fails catastrophically, immediately establish a rapid decision-making framework where experienced senior leadership can quickly assess the situation, authorize emergency response protocols, and mobilize resources without bureaucratic delays. This converts the destructive consequences of inadequate barriers into the constructive ability to respond decisively under crisis conditions. This transition is most effective during the immediate aftermath of a system failure or near-miss event, when the urgency creates organizational willingness to empower leadership with streamlined authority while the incident's lessons are fresh and actionable.

Key Factors: Crisis response infrastructure pre-exists in offshore operations; however, the transition assumes post-catastrophic conditions where trust in leadership is severely compromised; regulatory and liability frameworks actively prevent streamlined authority after major failures

Argumentation: The transition from catastrophic single-barrier failure to empowered decisive leadership faces severe structural barriers in the offshore drilling context. The Deepwater Horizon case demonstrates that after catastrophic failures, organizations face intense regulatory scrutiny, criminal investigations, and civil litigation that fundamentally prevent streamlined decision-making authority. BP faced over \$65 billion in penalties and years of regulatory oversight that required extensive documentation and approval chains rather than decisive autonomy. The transition assumes leadership credibility remains intact post-failure, but catastrophic incidents typically result in leadership replacement, organizational restructuring, and external oversight that deliberately constrains rapid decision-making. While emergency response protocols exist in offshore operations, they are designed for contained incidents, not system-wide failures where the adequacy of safety barriers is fundamentally questioned. The political and social resistance is enormous: regulators, public stakeholders, and workforce would resist granting expanded authority to the same leadership structure that presided over the failure.

Conditions for Success: Pre-established crisis governance frameworks with clear succession planning and external expert integration; regulatory pre-approval of emergency decision protocols that balance speed with accountability; demonstrated organizational learning through independent safety culture assessments; separation of incident response authority from operational management that failed; implementation during controlled exercises rather than actual catastrophes to build legitimacy before crisis conditions

28) **Tr28** = Transforms A4- (Silenced concerns lead to catastrophic failure) into T1+ (Proactive risk elimination) = Speak up before displacement begins. Mandate pre-shift briefings where anyone can voice safety concerns.

Establish a mandatory pre-shift safety briefing where any crew member can voice concerns about upcoming operations without fear of retaliation, with a specific checklist item requiring confirmation that negative pressure testing protocols will be followed before any displacement activities. This briefing should be documented with signatures from both operational leadership and floor personnel, creating an immediate channel for safety concerns to halt work before dangerous conditions develop. The transformation occurs by converting a culture of silenced concerns into one where proactive risk identification becomes the operational norm, making it standard practice to verify well integrity before proceeding. This intervention is most effective at the beginning of each operational shift, particularly before high-risk activities like well displacement, when the transition from planning to execution creates a natural checkpoint for ensuring all safety protocols—starting with pressure testing requirements—are clearly understood and will be enforced.

Key Factors: Minimal resource requirements, regulatory alignment, proven industry precedent

Argumentation: The mandatory pre-shift safety briefing with documented protocols is highly feasible because it requires minimal infrastructure investment (briefing templates, signature sheets) and leverages existing shift-change procedures already standard in offshore operations. Post-Macondo regulatory frameworks (API RP 75, BSEE requirements) explicitly mandate stop-work authority and documented safety communications, creating strong regulatory support rather than resistance. The intervention aligns with industry best practices already implemented successfully by major operators like Shell, ExxonMobil, and Chevron following the 2010 disaster. The timeline is immediate—briefings can begin within days once templates are created. The primary barrier is not structural but cultural: overcoming legacy hierarchical attitudes where floor workers historically deferred to supervisors. However, the offshore drilling industry has demonstrated substantial culture change post-Macondo, with companies investing heavily in safety culture programs that normalize worker empowerment. The documented signature requirement creates accountability without being bureaucratically burdensome, making adoption realistic across operations.

Conditions for Success: Visible management participation in early briefings to demonstrate cultural commitment, integration into existing permit-to-work systems rather than creating parallel processes, and linking briefing compliance to operational KPIs without punitive measures for work stoppages initiated during briefings

Output sample:

Estimated Feasibilities:

Step	Feasibility
21) Tr21+ Tier verification by risk to enable objective cement validation	0.79
22) Tr22+ Parallelize cement verification with BOP testing	0.87
23) Tr23+ Rapid safety teams with delegated authority	0.81
24) Tr24+ Tier stop-work thresholds to maintain momentum safely	0.72
25) Tr25+ Operators lead routine decisions, experts handle anomalies	0.80
26) Tr26+ Checklist fast, escalate automatically	0.84
27) Tr27+ Empower senior leaders to mobilize crisis response without delay	0.51
28) Tr28+ Mandatory pre-shift briefings where anyone can voice concerns	0.93

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Novel_Useful_Steps_in_Fig_1

Prompt: Identify which of proposed Tr steps are not present in the Commission's report but could add significant practical value in real-world operations.

Output Table. Tr steps that were not clearly stated in the report, and could add real value today

Suggested Tr step	Novelty
Tr8 — mandatory pre-shift briefings where anyone can raise concerns	The Commission did call for whistleblower protection, but a formal pre-shift speak-up checkpoint before high-risk work is a more concrete operational mechanism. People may have stop-work authority on paper, yet concerns still get muted in operations.
Tr3 — rapid safety teams with delegated authority	The report emphasized stronger safety systems and accountability, but not a small multidisciplinary team with delegated go/no-go authority during critical phases. That could help today by reducing the gap between formal rules and real-time decision quality.
Tr6 — checklist fast, escalate automatically	The Commission focused on barrier validation and decision failures, but not on a standardized rapid field checklist tied to automatic expert escalation. That could reduce reliance on memory, hierarchy, and improvisation.
Tr2 — parallelize cement verification with BOP testing	The report cared deeply about cement, BOP reliability, and response capability, but not about workflow design to remove unnecessary sequencing delays. This could help to preserve safety without turning verification into a scheduling bottleneck.

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Transition_Feasibilities_in_Fig_3

Prompt: Estimate the practical Feasibility (0 to 1) of each of the following steps (1-8) below. Assume that each step can influence other step(s) in the following combinations:

- a) Ac1+ and Re1+ belong to the same causality circle.
- b) Ac2+ and Re2+ belong to the same causality circle.
- c) Tr1+ and Tr2+ and Tr3+ and Tr4+ belong to the same causality circle.
- d) Ac1+ and Re1+ and Ac2+ and Re2+ and Tr1+ and Tr2+ and Tr3+ and Tr4+ belong to the same causality circle.

[Inserted here were the outputs of Eye Opener-generated transition steps. The starting step:

1) **Ac1+** = Transforms T1- (Operational paralysis from excessive verification) into A1+ (Operational flexibility enables progress) = Match testing intensity to risk.

Use tiered verification protocols matched to documented risk levels.

Establish tiered verification protocols with predefined decision trees that categorize well conditions into clear risk levels, allowing crews to apply proportionate testing requirements based on objective formation pressure data, completion geometry, and operational history. This converts rigid halt requirements into structured flexibility by providing crews with explicit criteria for when standard verification suffices versus when enhanced testing is mandatory, enabling operations to progress efficiently under normal conditions while automatically escalating verification intensity when risk indicators cross documented thresholds.

Key Factors: Industry regulatory alignment, technical standardization capacity, operational culture shift from absolute rules to risk-based decision frameworks

Argumentation: The transition is moderately feasible because tiered verification protocols align with existing industry moves toward risk-based safety management systems (e.g., API RP 96, ISO 31000). Post-Macondo, offshore operators have invested heavily in decision-support systems and formal risk assessment frameworks, creating technical infrastructure for implementation. However, the cultural challenge remains significant: the original absolute rule ("no test = no displacement") emerged precisely because flexible interpretation failed catastrophically at Macondo. Regulatory bodies like BSEE would need to approve risk-tiered approaches, requiring demonstration that structured flexibility doesn't recreate pre-Macondo vulnerabilities. Precedent exists in aviation (e.g., risk-based maintenance intervals) and nuclear power (defense-in-depth with graded requirements), showing that industries can successfully implement proportionate protocols after major accidents. The 10+ years since Macondo provides sufficient maturity for this evolution, though resistance from liability concerns and "never again" institutional memory remains substantial.

Conditions for Success: Regulatory pre-approval of risk categorization frameworks with explicit safe harbors for operators following approved decision trees; industry-wide standardization through API/IADC working groups to ensure consistency; third-party validation of risk matrices against historical incident data; mandatory training programs demonstrating crew competency in applying tiered protocols; integration with real-time monitoring systems that automatically flag threshold crossings; liability protection provisions that shield operators making good-faith decisions within approved frameworks from litigation targeting discretionary judgment

2) **Re1+** = Transforming A1- (Uncontrolled blowout from ignored warnings) into T1+ (Verified well integrity ensures safety) = Stop, test, verify, then proceed. ... and so on. In total 8 steps were considered in this prompt]

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Output sample:

Estimated feasibility

Step	Feasibility	Rationale
1) Ac1+ — Tiered verification matched to risk	0.62	Technically doable and attractive operationally, but it reintroduces discretion into an area where rigid rules were created precisely because discretion failed. Feasible, but only with tight standardization and regulator-approved decision trees.
2) Re1+ — Stop, test, verify before displacement	0.90	This is the most practically controllable and already closest to post-Macondo regulatory reality. Clear trigger, clear checkpoint, clear enforcement. High feasibility.
3) Ac2+ — Build verification into operations upfront	0.84	Very feasible because it mainly requires planning discipline, schedule integration, and standardized workflows rather than a conceptual shift in safety philosophy.
4) Re2+ — Independent third-party review before high-risk operations	0.74	Feasible, but dependent on verifier capacity, independence, and avoiding delay bottlenecks. Strong on paper; somewhat harder at scale in real operations.
5) Tr1+ — Tier verification rigor by operational risk	0.66	Similar to Step 1, but slightly more feasible because it focuses on matching assurance to barrier criticality rather than broadly softening an absolute rule. Still vulnerable to gaming and classification disputes.
6) Tr2+ — Tier cement verification by risk level	0.69	More feasible than general tiering because cement jobs can be classified using clearer technical thresholds. Still requires trusted criteria and auditability.

Step	Feasibility	Rationale
7) Tr3+ — Rapid expert panels when anomalies emerge	0.78	Operationally realistic with modern communications and predefined escalation protocols. Harder than a simple stop-rule, but quite feasible if expert availability is contractually guaranteed.
8) T4+ — Independent expert panel validates well integrity before operations	0.76	Strong practical logic and post-accident legitimacy. Slightly less feasible than Step 2 because it depends on true independence, panel quality, and avoiding ritualized signoff.

Sequence Permutations with Feasibilities for Table 1.

R – feasibility, P – probability normalized to sum up to 100%

(A) T-only sequences	(B) T/A sequences for T1 - T2 - T3 - T4
R = 0.75 P = 18.8% T1 → T2 → T3 → T4	R = 0.15 P = 15% T1 → T2 → T3 → T4 → A1 → A2 → A3 → A4
R = 0.72 P = 18.1% T1 → T3 → T2 → T4	R = 0.15 P = 15% T1 → T2 → A4 → T3 → A1 → A2 → T4 → A3
R = 0.72 P = 18.1% T1 → T3 → T4 → T2	R = 0.15 P = 15% T1 → T2 → A3 → A4 → A1 → A2 → T3 → T4
R = 0.72 P = 18.1% T1 → T4 → T2 → T3	R = 0.15 P = 15% T1 → A3 → T2 → A4 → A1 → T3 → A2 → T4
R = 0.72 P = 18.1% T1 → T4 → T3 → T2	R = 0.15 P = 15% T1 → A3 → A4 → T2 → A1 → T3 → T4 → A2
R = 0.35 P = 8.8% T1 → T2 → T4 → T3	R = 0.15 P = 15% T1 → A2 → A3 → A4 → A1 → T2 → T3 → T4
	R = 0.05 P = 5% T1 → T2 → T3 → A4 → A1 → A2 → A3 → T4
	R = 0.05 P = 5% T1 → A4 → T2 → T3 → A1 → T4 → A2 → A3