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APPLYING TOC AND TRIZ TO ACCELERATE BASIC PERMITTING IN POWER INFRASTRUCTURE DEVELOPMENT

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ABSTRACT

The acceleration of basic permit issuance for large-scale infrastructure projects is often constrained not by policy intent, but by structural trade-offs between processing speed and regulatory compliance. Although prior studies have identified systemic drivers of permitting delays—such as institutional capability gaps and sequential workflow dependencies—there remains limited methodological guidance on how to resolve these constraints without weakening legal safeguards. This study addresses that gap by integrating the Theory of Constraints (TOC) and the Theory of Inventive Problem Solving (TRIZ) to analyze the basic permitting process in Indonesia's electricity sector. Drawing on empirically identified systemic constraints from a precursor study, a Current Reality Tree (CRT) is constructed to trace the convergence of multiple undesirable effects into a core system conflict. TRIZ contradiction analysis is then employed to transform this conflict into non-compromising solution directions. The proposed interventions—including risk-based verification redistribution, modular workflow segmentation, and hybrid digital facilitation—are synthesized into a Future Reality Tree (FRT) to assess their logical sufficiency. The findings demonstrate that administrative efficiency and regulatory assurance need not be treated as mutually exclusive objectives. By resolving underlying structural contradictions, permit throughput can be accelerated while preserving compliance integrity. The study contributes a transferable analytical framework for governance reform that moves beyond diagnostic analysis toward structured contradiction resolution.

Keywords: Theory of constraints; Theory of inventive problem solving; Permit issuance; Regulatory governance; Infrastructure development

1. INTRODUCTION

Timely issuance of basic permits during the pre-construction phase is a critical prerequisite for infrastructure project execution, particularly in large-scale energy projects characterized by multi-actor governance and complex regulatory oversight. In practice, delays in basic permits frequently emerge as the dominant bottleneck constraining downstream land acquisition and construction activities. Slippages at this stage often cascade across the entire project lifecycle, weakening investment certainty and undermining execution reliability.

In response, governments have increasingly introduced risk-based licensing regimes and digital one-stop systems to streamline permit processing. Despite these reforms, improvements in speed and predictability have not been consistently realized at the operational level. Much of the existing literature explains permitting delays through the lenses of regulatory design, compliance behavior, or institutional implementation gaps. These perspectives are valuable, yet they primarily diagnose symptoms or structural conditions rather than offering structured mechanisms for resolving the underlying system tensions.

A preceding diagnostic study (Author, 202X) demonstrated that permitting delays in Indonesia's electricity sector are not isolated administrative failures but emergent properties of interacting systemic factors, including institutional capability variation, sequential verification dependencies, and transitional regulatory ambiguity. While this diagnostic insight clarifies why delays persist, it does not directly address how the structural conflict embedded in the system can be resolved without introducing new trade-offs.

The core challenge lies in overcoming the apparent contradiction between accelerating permit issuance and preserving the rigor of legal and environmental verification. Conventional process improvement approaches often treat these objectives as competing priorities, forcing compromises between speed and compliance. This study advances beyond such trade-off logic by introducing an integrated Theory of Constraints (TOC) and Theory of Inventive Problem Solving (TRIZ) framework as a structured contradiction-resolution approach. Rather than merely identifying bottlenecks, the integration enables systematic transformation of core conflicts into non-compromising solution directions.

TOC is first used to identify the binding constraint and articulate the underlying core conflict shaping system behavior. TRIZ is subsequently employed to resolve this contradiction through structured inventive principles. By combining these frameworks, the study moves beyond diagnostic analysis toward methodologically grounded solution design. The central research question is therefore: How can system-level contradictions between permit acceleration and regulatory assurance be resolved to improve predictability without compromising compliance integrity?

Beyond its analytical contribution, this study supports PLN's knowledge management agenda by codifying and institutionalizing structured problem-solving practices for pre-construction permitting in complex governance settings (Budiyono et al., 2024).

2. LITERATURE REVIEW

2.1. Theory of Constraints (TOC) in Non-Manufacturing Contexts

The Theory of Constraints (TOC) has progressively evolved from its origins in manufacturing into a general-purpose systems improvement framework applicable to service and public-sector environments. Central to TOC's relevance beyond manufacturing is its emphasis on identifying a dominant system constraint and using cause–effect logic—rather than local optimization—to improve overall performance.

Knaggs (2013) provides early empirical evidence that TOC constructs remain valid in non-manufacturing contexts, demonstrating that service and administrative processes are often governed by policy, behavioral, or decision constraints rather than physical capacity limits. In such settings, TOC thinking process tools—particularly the Current Reality Tree (CRT) and Core Conflict Diagram (CCD)—are critical for diagnosing systemic causes of underperformance.

Applications in service operations further illustrate TOC's versatility. Groop (2012) applies TOC to home care services, showing that productivity limitations stem from coordination rules and scheduling logic rather than staff availability. In the public sector, Bauer et al. (2019) demonstrate how CRTs and CCDs can uncover policy-induced conflicts in healthcare delivery, enabling targeted interventions that improve flow without compromising service quality. More recent case studies reinforce these insights; Knop (2025) highlights the effectiveness of TOC thinking tools in managing organizational constraints, while Xiong et al. (2019) show that lean–TOC hybrids can systematically eliminate waste in non-manufacturing processes.

2.2. TRIZ and Contradiction-Based Problem

Solving in Complex Systems

The Theory of Inventive Problem Solving (TRIZ) provides a structured framework for addressing complex problems characterized by persistent trade-offs. At its core, TRIZ is built on the premise that many system failures arise from unresolved contradictions, where improving one performance dimension systematically degrades another. Unlike optimization approaches that seek compromise solutions, TRIZ promotes a non–trade-off logic by identifying inventive principles that enable the simultaneous satisfaction of competing requirements.

In engineering and design contexts, contradiction-based reasoning has been shown to enhance innovative outcomes. Ko, Lu, and Lee (2016) demonstrate that formalizing design problems as explicit contradictions improves solution quality and reduces reliance on incremental improvement. Their work highlights the analytical value of separating the "improving" and "worsening" characteristics of a system, a logic that is directly transferable to organizational and administrative decision-making where competing policy objectives frequently coexist.

Beyond product design, TRIZ has been applied in non-technical domains to structure problem diagnosis and solution generation. Tan, Ng, and Noor (2021) illustrate how TRIZ principles can be assimilated into complex human-centered systems, showing that contradiction analysis can guide systematic intervention even when outcomes are influenced by behavioral and contextual factors. Educational and organizational applications further demonstrate TRIZ's versatility (Bozhik et al., 2023), suggesting that TRIZ's contradiction-based, non-compromising logic is well suited for governance systems where performance improvements must reconcile efficiency, accountability, and reliability.

2.3. Research Gap and Conceptual Positioning

Literature consistently identifies licensing procedures, regulatory layering, and inter-agency coordination as primary drivers of delay (Liscow, 2025; Love et al., 2015; Wang et al., 2022). While digital licensing reforms show measurable gains, limits to automation remain (Zahara et al., 2023).

Systems thinking research frames permitting performance as an emergent property of interacting subsystems (van der Heijden, 2022; Nguyen et al., 2023). While TOC applications contribute rigorous causal diagnostics (Knaggs, 2013; Bauer et al., 2019), they offer limited guidance on resolving identified conflicts without introducing new trade-offs. Conversely, TRIZ offers structured contradiction-resolution logic but remains underdeveloped in regulatory applications.

Table 1 synthesizes all referenced literature across Sections 2, systematically mapping their analytical focus, methodological contribution, and limitations. This positioning defines the research gap addressed by this study: This study addresses the absence of an integrated TOC–TRIZ framework tailored to complex permitting systems.

Table 1: Comprehensive Literature Mapping for Sections 2

Reference	Primary Focus	Key Contribution	Limitation for Permitting Systems
Knaggs (2013)	TOC beyond manufacturing	Validates TOC in services	Limited solution synthesis
Groop (2012)	TOC in field services	Identifies policy-driven constraints	Context-specific
Bauer et al. (2019)	TOC in public healthcare	Applies CRT/CCD to policy conflicts	Stops at diagnosis
Ko et al. (2016)	TRIZ contradiction logic	Formalizes non–trade-off reasoning	Engineering-centric
Tan et al. (2021)	TRIZ in human systems	Extends TRIZ beyond technical design	Indirect policy relevance
Bozhik et al. (2023)	TRIZ in education	Demonstrates structured creative reasoning	Limited governance application

3. RESEARCH QUESTIONS

1. How do empirically identified undesirable effects converge into a dominant constraint and core conflict that governs permit processing performance?
2. What fundamental system-level contradictions underlie the observed trade-offs between permit acceleration, regulatory assurance, coordination, and governance stability?
3. How can an integrated TOC–TRIZ approach be used to derive solution directions that accelerate basic permit issuance while preserving legal defensibility and institutional accountability?

4. METHODOLOGY

4.1. Research Design

This study employs a qualitative, systems-oriented research design aimed at resolving structural constraints in the basic permitting process. The methodological approach follows a staged integration of the Theory of Constraints (TOC) thinking processes and the Theory of Inventive Problem Solving (TRIZ). The design is sequential: TOC is first used to diagnose and structure the system constraint, and TRIZ is subsequently applied to resolve the identified contradiction without compromising system objectives. This integrated

logic is consistent with established TOC–TRIZ applications in complex organizational settings.

4.2. Constraint Identification Using TOC Thinking Processes

Building on the undesirable effects (UDEs) identified in the precursor analysis, TOC thinking processes are used to determine the dominant constraint limiting overall permitting throughput. A Current Reality Tree (CRT) is constructed to map the cause–effect relationships among UDEs and to trace their convergence into a limited number of root drivers.

From the CRT, a Core Conflict Diagram (CCD) is derived to articulate the fundamental tension governing system behavior. In this case, the conflict reflects the structural trade-off between accelerating permit issuance and maintaining regulatory accuracy and compliance.

4.3. Formulation of System-Level Contradictions

To prepare the conflict for structured solution design, the CCD is translated into explicit system-level contradictions. Each contradiction represents a policy or process orientation that improves one critical system attribute while simultaneously degrading another. This formalization enables the conflict to be analyzed using TRIZ contradiction logic rather than treated as a normative policy dilemma.

4.4. TRIZ-Based Solution Development

TRIZ is applied to generate solution directions capable of resolving the identified contradictions without forcing trade-offs. Using the TRIZ contradiction matrix and relevant inventive principles, alternative solution pathways are derived for each system-level contradiction.

To maintain alignment with TOC logic, the proposed solutions are categorized into two levels:

1. Systemic-level solutions, which modify governance logic, workflow architecture, or regulatory decision rules; and
2. Operational-level solutions, which can be implemented directly by the infrastructure owner (PLN) without requiring regulatory reform.

This distinction ensures that solution development remains consistent with the location and nature of the identified constraint.

4.5. Validation and Logical Sufficiency

The selected interventions are synthesized into a Future Reality Tree (FRT) to test their logical sufficiency. The FRT evaluates whether the proposed changes eliminate or substantially mitigate the original undesirable effects while avoiding the emergence of new negative branches. This step closes the analytical loop by linking contradiction resolution to system-level performance improvement.

5. UNDESIRABLE EFFECTS (UDES) IDENTIFICATION

To structure the patterns of delay and variability identified in the diagnostic phase into analytically meaningful units, the findings were translated into Undesirable Effects (UDEs). UDEs serve two purposes: they summarize performance challenges in a descriptive, neutral manner, and they act as the starting point for the Current Reality Tree (CRT).

Table 2: Undesirable Effects (UDEs) Derived from Diagnostic Study

UDE Code	Undesirable Effect
UDE1	The overall duration of permit processing at the local level is often longer and less predictable than expected, due to variations in workflow structure and administrative capacity.
UDE2	Processing performance differs substantially across regions, reflecting variations in institutional readiness and regulatory/digital adaptation.
UDE3	Document clarifications or revisions can pause the progression of permit stages because several verification tasks remain sequentially dependent.
UDE4	Expected decision timelines are not consistently met, partly because escalation mechanisms and timeline references differ across regions.
UDE5	Some applications experience periods of limited visible progress due to distributed responsibilities and the absence of shared tracking systems.
UDE6	Differences in regulatory interpretation during transitional periods may create repeated verification loops or clarification cycles.
UDE7	Non-PSN projects do not consistently benefit from priority pathways, resulting in variable processing speed.
UDE8	Digital systems standardize submissions, but several verification activities still rely on manual confirmation, limiting efficiency gains.
UDE9	Processing timelines may be influenced by contextual administrative considerations, particularly during regulatory transition or peak workload.
UDE10	The overall end-to-end permit cycle remains longer than desired for timely project execution.

Taken together, these ten UDEs present a concise picture of how the basic permit process currently behaves. The UDEs consistently co-occur, suggesting underlying interactions among

institutional capacity, workflow structures, and regulatory clarity.

6. CONSTRAINT DIAGNOSIS USING CURRENT REALITY TREE (CRT)

The Current Reality Tree (CRT) provides a structured explanation of why the basic permit process persistently produces an extended end-to-end cycle (UDE10). In accordance with the Theory of Constraints, the CRT treats this outcome as an emergent property of the system—one that arises from reinforcing interactions among operational practices and coordination structures.

At the system level, UDE10 is directly reinforced by three interrelated effects: *long and unpredictable processing duration (UDE1)*, *inconsistent adherence to expected timelines (UDE4)*, and *regional variation in processing behavior (UDE2)*. Together, these effects explain why permit issuance takes longer than intended and why its performance is difficult to manage proactively.

UDE1 reflects a fundamental characteristic of the verification process itself. The CRT indicates that *document clarifications or revisions (UDE3)* frequently interrupt process continuity because verification activities remain sequentially dependent. This effect is amplified by *manual backend verification and partial digital integration (UDE8)*. As hybrid manual–digital configurations combine rigid formal procedures with human validation discretion, processing duration becomes both longer and less predictable.

UDE4, the inconsistent attainment of expected timelines, emerges from complementary interactions. The CRT shows that *limited shared visibility and tracking across institutions (UDE5)* reduces the system's ability to recognize stalled cases early. This condition is further reinforced by *variation in access to priority pathways (UDE7)*, where prioritization variability weakens throughput control and undermines flow stability.

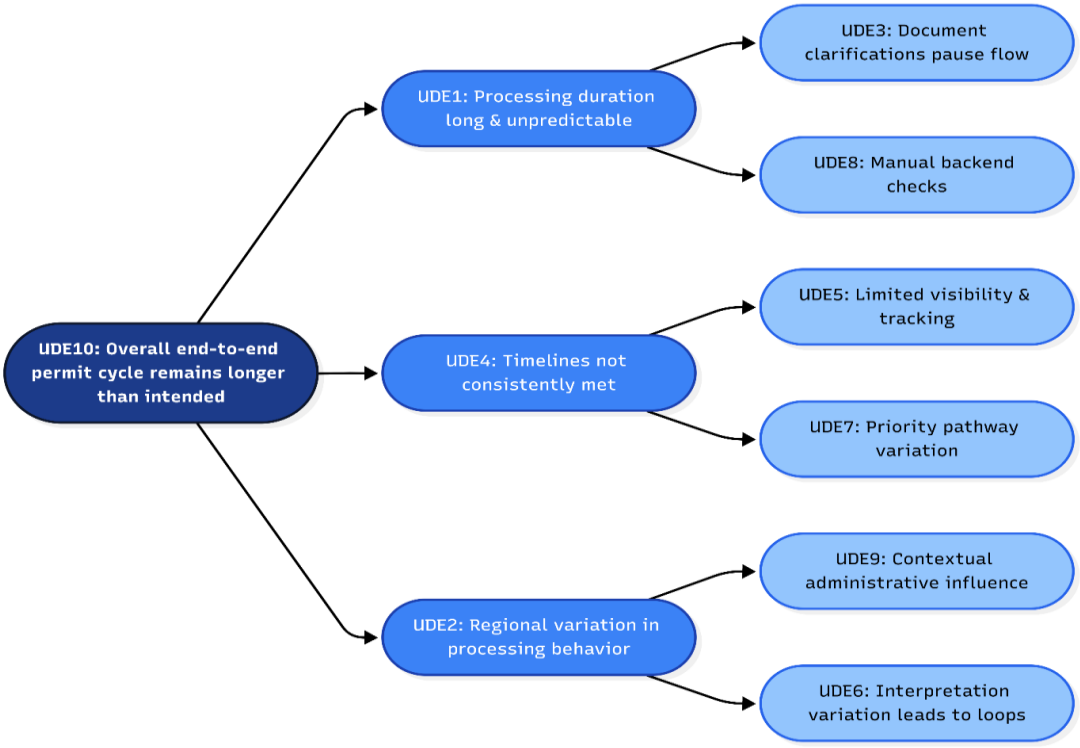

Figure 2: Current Reality Tree (CRT) for Basic Permit Issuance Delays

UDE2 captures the spatial dimension of system behavior: observable variation in processing practices across regions. The CRT links this variation to the interaction between *contextual administrative considerations (UDE9)* and *differences in regulatory interpretation (UDE6)*. Variations in workload and institutional caution influence how similar cases are handled. When combined with sequential workflows, such variation becomes a significant contributor to uneven system performance.

Importantly, the CRT demonstrates that UDE1, UDE4, and UDE2 are mutually reinforcing. These reinforcing dynamics repeatedly drive the system toward UDE10—the prolonged end-to-end permit cycle—despite localized improvements.

7. CORE CONFLICT ANALYSIS

The analysis of the Current Reality Tree reveals that the basic permit system operates under a structural tension characteristic of complex, multi-

agency regulatory environments. Although all institutions involved share the objective of supporting infrastructure development, the system is shaped by two legitimate but competing requirements that pull operational behavior in opposing directions.

On one hand, *timeliness and predictability* are essential for enabling infrastructure execution. This corresponds to the first requirement: the system must **accelerate workflow progression** to meet project delivery needs. On the other hand, *regulatory accuracy and assurance* are equally essential. This corresponds to the second requirement: the system must **preserve cautious, sequential, and comprehensive verification** to maintain regulatory integrity.

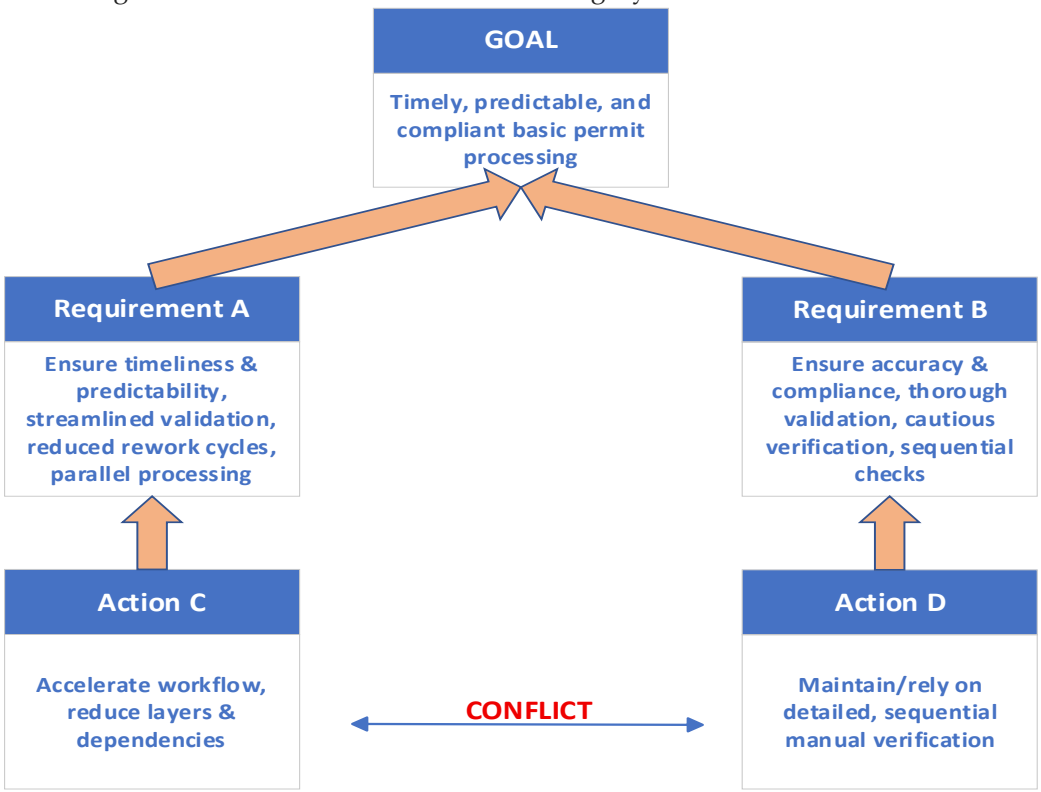

Figure 3: Core Conflict Diagram (CCD) of the Basic Permitting System

Each requirement leads to a logical operational response. To support speed, actors aim to simplify dependencies and increase parallelism. To ensure accuracy, actors maintain granular validation steps and rely on sequential confirmation. Both tendencies are rational and protect legitimate institutional objectives.

However, when these two operational tendencies coexist within a process that depends on multiple agencies and evolving regulatory contexts, they generate an inherent structural conflict: *efforts to accelerate processing through reduced sequential verification appear to increase perceived risk*, while *efforts to maintain detailed sequential verification appear to limit the potential for acceleration*. Because neither requirement can be fully abandoned, the system oscillates between these two poles, resulting in the systemic effects observed in the CRT. This **core conflict** is the target for the TRIZ-based solution mapping.

8. TRIZ-BASED CONTRADICTION ANALYSIS AND SOLUTION MAPPING

To translate the abstract core conflict into a form that can be analytically resolved, the conflict is decomposed into five fundamental contradictions. Each contradiction represents a persistent decision dilemma that repeatedly generates the UDEs observed in the CRT.

8.1. Contradiction 1: Speed vs. Verification Accuracy

The most fundamental tension concerns the relationship between processing speed and verification accuracy. Acceleration is necessary but interacts directly with the depth and consistency of verification.

"IF the permitting system emphasizes meeting project-driven timelines by prioritizing faster completion of basic permits, THEN the overall speed and timeliness of permit issuance improve, BUT the accuracy and depth of technical and regulatory verification decline, increasing the likelihood of errors, rework, or downstream non-compliance."

Table 3: Contradiction 1: Speed vs. Verification Accuracy (9 vs. 27) - TRIZ Inventive Principles: 11, 35, 27, 28

TRIZ No.	Inventive Principle	Systemic Solution Direction	Practical Solution
11	Beforehand Cushioning	Introduce preventive safeguards to absorb risks associated with accelerated processing.	Establish **internal pre-screening and compliance checklists** (technical, spatial, regulatory) prior to formal OSS submission to prevent deficiencies from reaching regional authorities.
35	Parameter Changes	Adjust verification depth based on contextual risk rather than applying uniform scrutiny.	Implement **risk-based document packaging**, whereby high-risk projects require enhanced documentation while low-risk cases follow a simplified but compliant set.
27	Cheap Short-Living Objects	Use temporary or provisional validation artifacts to support early-stage review.	Submit **preliminary technical notes or provisional spatial validations** as supporting documents before full verification is finalized.
28	Mechanics Substitution	Replace manual verification with automated or semi-automated mechanisms where feasible.	Deploy **rule-based document completeness checks** and automated format validation prior to OSS submission.

8.2. Contradiction 2: Procedural Consistency vs. Contextual Flexibility

A second contradiction emerges from the tension between regulatory uniformity and local feasibility, where national reforms impose standardized procedures on regions with varying capacities.

"IF basic permit procedures are implemented uniformly across regions without explicit differentiation based on local administrative capacity, THEN procedural consistency and predictability across jurisdictions improve, BUT local flexibility in adapting the process to contextual constraints decreases, leading to friction and delays in capacity-limited regions."

Table 4: Contradiction 2: Procedural Consistency vs. Contextual Flexibility (33 vs. 35) - TRIZ Inventive Principles: 15, 34, 1, 16

TRIZ No.	Inventive Principle	Systemic Solution Direction	Practical Solution
15	Dynamization	N/A	N/A
34	Discarding and Recovering	Remove non-essential procedural elements when they do not add regulatory value.	Exclude **non-critical supporting documents** for low-complexity regions while maintaining compliance with core requirements.
1	Segmentation	Decompose standardized procedures into manageable components (general and specific documents).	Break permit submissions into specific or **administrative sub-packages** that can be reviewed independently according to local capacity.
16	Partial or Excessive Action	Apply only the necessary level of action instead of uniform full compliance.	Adopt a **partial-compliance-first approach**, completing additional requirements only when formally requested.

8.3. Contradiction 3: Process Automation vs. Institutional Readiness

The third contradiction relates to digital reform. Automation is intended to standardize processing, yet digital capability and system familiarity vary significantly.

"IF the permit process relies predominantly on automated workflows through the OSS platform as the primary mode of operation, THEN administrative efficiency and system-level throughput improve, BUT institutional readiness and effective process reliability worsen in regions with limited digital capability and system familiarity."

Table 5: Contradiction 3: Process Automation vs. Institutional Readiness (39 vs. 27) - TRIZ Inventive Principles: 1, 35, 10, 38

TRIZ No.	Inventive Principle	Systemic Solution Direction	Practical Solution
1	Segmentation	Separate automated and manual process components.	Provide **hybrid processing pathways**, combining OSS automation with internal manual facilitation for specific projects.
35	Parameter Changes	Adjust the intensity of automation based on institutional readiness.	Define **graduated automation levels** for different regions and specific projects.
10	Prior Action	N/A	N/A
38	Strong Oxidants (Intensification)	Apply intensified enabling mechanisms to accelerate adoption.	Provide **intensive technical assistance and rapid-response support** for regions facing persistent OSS difficulties.

8.4. Contradiction 4: Parallel Processing Speed vs. Coordination Complexity

Parallel execution of verification tasks is often proposed to accelerate processing, yet it introduces new coordination challenges.

"IF verification activities across multiple agencies are executed in parallel to reduce waiting time between process steps, THEN the total duration of permit processing decreases, BUT control complexity and coordination difficulty increase, making accountability and process oversight harder to maintain."

Table 6: Contradiction 4: Parallel Processing Speed vs. Coordination Complexity (9 vs. 36) - TRIZ Inventive Principles: 10, 28, 4, 34

TRIZ No.	Inventive Principle	Systemic Solution Direction	Practical Solution
10	Prior Action	Prepare coordination structures before parallel execution begins.	Assign a **dedicated internal coordination lead** prior to initiating parallel permit processing.
28	Mechanics Substitution	Replace manual coordination with digital monitoring tools.	Use a **simple internal permit-tracking dashboard** to monitor cross-agency progress.
4	Asymmetry	Assign asymmetric roles to reduce coordination burden.	Designate **one key reference authority** rather than treating all agencies as equal coordinators.
34	Discarding and Recovering	Eliminate redundant coordination loops.	Remove **repetitive coordination meetings** that do not result in new decisions.

8.5. Contradiction 5: Regulatory Alignment vs. Local Decision Autonomy

A structural tension arises from the governance relationship between central authorities and local implementing agencies, where guidance interacts with local discretion.

"IF stronger central oversight is applied to ensure alignment with national policy objectives and regulatory interpretations, THEN regulatory coherence and accountability across regions improve, BUT local administrative autonomy and contextual responsiveness deteriorate."

Table 7: Contradiction 5: Regulatory Alignment vs. Local Decision Autonomy (27 vs. 35) - TRIZ Inventive Principles: 13, 35, 8, 24

TRIZ No.	Inventive Principle	Systemic Solution Direction	Practical Solution
13	The Other Way Around	Reverse the direction of interpretive guidance.	Submit **PLN-prepared regulatory interpretation notes** as a reference for local review.
35	Parameter Changes	Adjust the degree of required alignment based on its risks.	Distinguish **mandatory versus optional regulatory elements** within permit submissions.
8	Anti-Weight	Reduce the perceived burden of regulatory alignment.	Provide a **concise compliance matrix** and up to date regulations to minimize reinterpretation effort by local authorities.
24	Intermediary	Introduce mediating mechanisms between governance levels.	Utilize **liaison officers or coordination forums** to bridge central–local interpretation gaps.

9. DISCUSSION

The TRIZ-based solution mapping provides a structured and theory-driven set of intervention logics. However, consistent with the Theory of Constraints (TOC), solution validity depends on whether the selected interventions directly address the dominant system constraint. This discussion critically synthesizes the proposed solutions.

9.1. Systemic-Level Solutions and Governance Implications

Systemic solutions target the underlying decision logic, governance arrangements, and process architecture. Across the five contradictions, three systemic solution directions emerge as particularly robust.

First, **risk-based differentiation of verification depth** represents a critical systemic lever. The TRIZ-based solutions suggest that verification effort can be redistributed—rather than uniformly reduced—by differentiating between low-, medium-, and high-risk permit contexts. This approach directly resolves the *Speed vs. Verification Accuracy* contradiction by preserving regulatory assurance while avoiding unnecessary scrutiny for low-risk cases.

Second, **modularization and segmentation of permit workflows** provide a structural mechanism for reconciling procedural consistency with contextual flexibility. Standardization is preserved at the rule and documentation level, while execution pathways become adaptable to local capacity and complexity. This design logic addresses regional heterogeneity without fragmenting governance or undermining regulatory coherence, offering a practical resolution to the *Procedural Consistency vs. Contextual Flexibility* contradiction.

Third, the analysis highlights the importance of **graduated digitalization aligned with institutional readiness**. Rather than treating automation as a binary requirement, the proposed solutions conceptualize digitalization as a staged capability. Automation is intensified where readiness exists and complemented by hybrid support where it does not. This reframing prevents digital systems from becoming secondary constraints and directly addresses the *Process Automation vs. Institutional Readiness* contradiction.

9.2. Practical-Level Solutions Implementable by PLN

Practical solutions focus on actions that can be implemented directly by PLN without regulatory change. These interventions are prioritized because they can generate immediate throughput improvements.

A central practical intervention is the establishment of **internal pre-verification and quality-gating mechanisms** prior to formal OSS submission. By identifying technical, spatial, and

documentation deficiencies early, PLN creates a quality gate that reduces iterative clarification cycles with regional authorities. This directly exploits the dominant bottleneck identified in the CRT and operationalizes TRIZ principles such as *Beforehand Cushioning* and *Prior Action* entirely within PLN's control.

Another high-impact intervention is the strategic use of **provisional or conditional documentation artifacts**. These artifacts allow the review process to advance without requiring full finalization of all verification elements upfront. Importantly, they do not bypass regulatory requirements but instead restructure the timing of verification. This approach is particularly effective in reducing risk-averse behavior among decision-makers.

In addition, **hybrid digital–manual support mechanisms** emerge as a critical practical solution. Rather than forcing uniform OSS usage across regions, PLN can provide internal facilitation, data preparation, and submission assistance tailored to local readiness levels. This approach supports the digital reform agenda while mitigating delays caused by uneven institutional capacity.

10. FUTURE REALITY TREE (FRT) AND VALIDATION

To test the logical sufficiency of the proposed solutions, the study employs the **Future Reality Tree (FRT)**. The FRT validates that the selected interventions—referred to as *injections*—can plausibly eliminate the dominant Undesirable Effects (UDEs) without creating new undesirable consequences.

10.1. Selected Injections

1. **INJ1:** Internal pre-verification and quality gating prior to OSS submission
2. **INJ2:** Risk-based differentiation of verification depth and document requirements
3. **INJ3:** Use of provisional and conditional verification artifacts
4. **INJ4:** Modular and segmented permit submission structure
5. **INJ5:** Hybrid automation support aligned with regional institutional readiness
6. **INJ6:** Structured coordination and tracking for parallel processing
7. **INJ7:** System-embedded accountability and decision-protection mechanisms

10.2. Causal Logic and Elimination of UDEs

1. **Reduction of rework and iteration:** If *INJ1 (pre-verification)* is implemented, permit submissions enter the OSS platform with higher initial completeness. As a result, clarification requests decrease, leading to a reduction in rework cycles (resolving UDE3).
2. **Right-sizing verification effort:** If *INJ2 (risk-based differentiation)* is applied, verification resources are concentrated on permits with higher regulatory exposure, while low-risk cases avoid uniform scrutiny (resolving UDE1).
3. **Stabilization of digital process performance:** If *INJ5 (hybrid automation)* is implemented, automation is applied where institutional capability supports it and complemented by facilitative support where it does not (resolving UDE8).
4. **Effective parallel processing:** If *INJ4 (modular submission)* and *INJ6 (structured coordination)* are implemented jointly, permit components can be reviewed in parallel under a clearly defined coordination structure. This reduces waiting time without escalating coordination complexity (resolving UDE5, UDE10).
5. **Reduction of risk-averse behavior:** If *INJ3 (provisional artifacts)* and *INJ7 (decision-protection mechanisms)* are implemented, decision-makers are able to engage earlier in the process without disproportionate risk exposure (resolving UDE9).

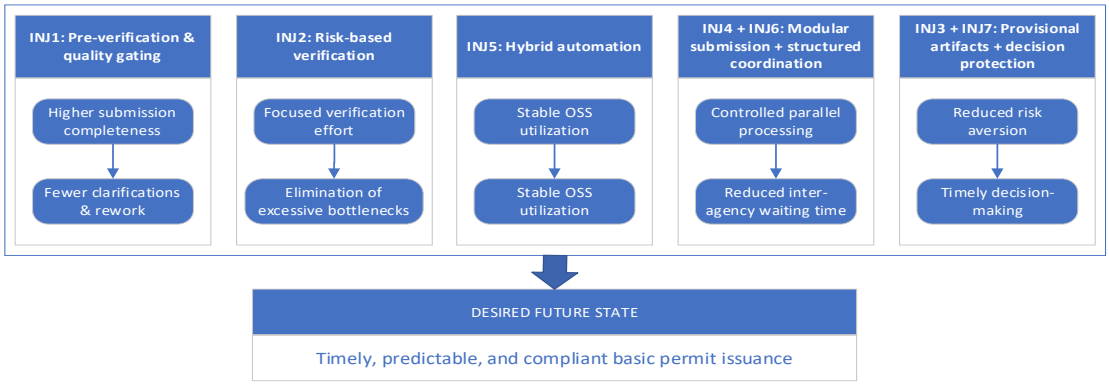

Figure 4: Future Reality Tree (FRT) for Accelerated Basic Permit Issuance

Resulting Future State: The FRT predicts that the causal convergence of these injections transforms the system into one characterized by reduced rework, balanced verification effort, stabilized digital performance, and timely decision-making—collectively constituting a state of **timely, predictable, and compliant basic permit issuance**.

11. CONCLUSION

This study addressed persistent extended processing time in the issuance of basic permits during the pre-construction stage of large-scale infrastructure projects by advancing an integrated TOC–TRIZ framework for structured contradiction resolution. Rather than treating permitting inefficiencies as isolated administrative shortcomings, the study conceptualized them as manifestations of deeper systemic conflicts embedded within governance design.

The analysis identified five system-level contradictions that sustain delay, each reflecting tensions between legitimate but competing performance objectives. Through TRIZ-based contradiction mapping, the study demonstrated that these tensions can be resolved without resorting to conventional trade-offs. By restructuring when, how, and by whom verification and decision-making activities are conducted, the proposed interventions realign system logic rather than merely accelerating individual process steps. The Future Reality Tree (FRT) further validated the logical sufficiency of these interventions, confirming that the dominant Undesirable Effects can be eliminated through coordinated systemic and operational injections.

Overall, the findings demonstrate that accelerating basic permit issuance does not require sacrificing regulatory rigor or accountability. Instead, performance improvement emerges from resolving embedded structural contradictions, enabling speed, predictability, and compliance to improve simultaneously. By moving beyond diagnostic analysis toward a methodologically grounded contradiction-resolution framework, this study reinforces the originality and transferability of the integrated TOC–TRIZ approach for complex, multi-actor administrative systems.

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