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## Rethinking Freight Transport: A Systemic Policy Model for Curbing Over Dimension Over Load (ODOL) in Indonesia

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**Abstract:** The persistent challenge of Over Dimension Over Load (ODOL) violations in Indonesia's freight transport system poses critical threats to road infrastructure integrity, traffic safety, and economic efficiency. Despite regulatory frameworks established through Ministry of Transportation directives, enforcement remains fragmented, and compliance rates remain alarmingly low. This study develops an integrated multimodal transportation policy model employing Soft Systems Methodology (SSM) to address systemic ODOL violations through coordinated stakeholder engagement, technology-enabled enforcement, and strategic modal integration. Drawing on comprehensive analysis of 100+ peer-reviewed publications (2020-2025), international regulatory standards, and empirical enforcement data, this research constructs a holistic framework that transcends traditional command-and-control approaches. The proposed model integrates Weigh-In-Motion (WIM) technology deployment, port-gate digital integration systems, progressive sanction mechanisms calibrated to infrastructure damage externalities, and multimodal freight corridor development. Through SSM's seven-stage methodology, the study maps complex stakeholder interactions among government agencies, transport operators, infrastructure managers, and enforcement authorities, revealing systemic bottlenecks and leverage points for policy intervention. Empirical evidence from Abu Dhabi demonstrates 61% overload prevalence in unregulated environments, while Indonesian enforcement unit performance evaluations expose critical gaps in inter-agency coordination and enforcement capacity. The research proposes a phased nationwide implementation strategy encompassing governance architecture establishment, targeted enforcement pilots in high-risk corridors, sanction calibration linked to quantified road damage costs, and complementary modal shift incentives. This SSM-informed policy model offers actionable pathways for Indonesia to achieve Zero ODOL objectives while maintaining freight system efficiency and stakeholder viability, contributing theoretical advancement in systems-based transportation governance and practical frameworks for developing-country freight policy reform.

**Keyword:** ODOL Violations, Multimodal Transportation Policy, Soft Systems Methodology, Freight Enforcement, Weigh-In-Motion Technology.

## INTRODUCTION

The problem of Over Dimension Over Load (ODOL) in Indonesia's freight transport system has reached a critical level that threatens the sustainability of national road infrastructure, traffic safety, and macroeconomic efficiency. Empirical data indicate that the prevalence of freight vehicles violating standard dimension and load limits reaches alarming proportions, with Weigh-In-Motion (WIM) studies in Abu Dhabi identifying that 61% of trucks passing weighing stations were overloaded during the analysis period, reflecting similar patterns observed in Indonesian logistics corridors [1]. This phenomenon is not merely a technical operational issue but rather a manifestation of systemic failure in transportation policy architecture involving complexity of stakeholder interactions, enforcement capacity limitations, and economic incentives misaligned with regulatory objectives.

The economic impact of ODOL violations is multidimensional and substantial. Quantitative research on infrastructure maintenance cost externalities demonstrates that even small proportions of overweight traffic significantly increase road maintenance costs, with vehicle damage functions (VDFs) exhibiting non-linear relationships to axial loads [2]. Studies on Indonesian toll roads indicate that maintenance cost escalation due to ODOL can reach significant multiples compared to full compliance scenarios, imposing negative externalities on road authorities and ultimately on society through higher taxes or tolls [3]. From a safety perspective, ODOL vehicles exhibit degraded vehicle dynamics characteristics, including longer braking distances, reduced lateral stability, and increased risk of structural component failure, contributing to higher fatal accident rates on corridors with high ODOL prevalence [4].

The Indonesian government's policy response to ODOL challenges has been articulated through a series of regulatory instruments, primarily Law Number 22 of 2009 on Road Traffic and Transportation, subsequently revised to Law Number 14 of 2024, along with various Ministry of Transportation Regulations governing vehicle dimension and load standards [5]. The Zero ODOL program launched by the Ministry of Transportation establishes ambitious targets to eliminate ODOL violations through enhanced supervision, increased capacity of Vehicle Weighing Implementation Units (UPPKB), and enforcement technology integration [6]. However, implementation evaluations reveal significant gaps between regulatory aspirations and operational reality in the field, including suboptimal inter-agency coordination between the Ministry of Transportation and Police, inadequate enforcement capacity, ineffective sanction mechanisms targeting drivers rather than owners or operators, and economic resistance from the freight transport industry [7][8].

The systemic complexity of ODOL problems demands a methodological approach capable of capturing dynamic interactions among system elements, accommodating multiple perspectives from diverse stakeholders, and identifying leverage points for effective policy intervention. Soft Systems Methodology (SSM), developed by Peter Checkland as an approach for addressing problem situations characterized by socio-technical complexity and structural uncertainty, offers an appropriate framework for multimodal transportation policy analysis and design [9]. SSM has been successfully applied in multi-level transportation governance contexts in Sweden, where the methodology was used to structure document analysis, group meetings, and stakeholder workshops to build conceptual models and stakeholder perspectives in sustainable transportation planning [10]. The SSM approach facilitates systematic exploration of different "weltanschauung" or worldviews of transport operators, law enforcement authorities, infrastructure managers, and policymakers, enabling identification of consensus points and conflict areas requiring negotiation and compromise.

Integration of multimodal concepts into ODOL reduction strategies offers a crucial yet often overlooked dimension in conventional policy discourse. The multimodal framework

focuses not only on law enforcement against road mode violations but integrates considerations of modal shift, alternative freight corridor development, and inter-modal transfer optimization to reduce pressure on vulnerable road infrastructure [11]. The Situation-Actor-Process / Lever-Action-Policy (SAP-LAP) approach applied to multimodal freight policy in developing countries demonstrates operationalization of actor prioritization and action matrices to identify leverage points, including dedicated freight corridors, road-rail modal shift, and public actor prioritization [12]. The Land Use, Transport & Energy Integration (LUTEI) framework further emphasizes the importance of integrating transportation policy with spatial planning and energy-environmental considerations to avoid modal interventions that merely shift problems to other domains without addressing root causes [13].

The Indonesian context presents unique challenges and opportunities for implementing SSM-based multimodal transportation policy models. As an archipelagic nation with 17,000+ islands and complex geography, Indonesia possesses an inherently multimodal transportation system involving combinations of roads, railways, seaports, and airports in the national logistics chain [14]. However, operational integration among modes remains weak, with most freight movement concentrated on road modes experiencing excessive pressure, particularly on main corridors such as North Coast Java (Pantura) and Trans-Sumatra [15]. Case studies at UPPKB Cekik and Trosobo reveal that enforcement units detect varying ODOL violation patterns and recommend infrastructure upgrades (ATCS, weighbridges), SOP strengthening, and inter-agency MOUs [16][17]. Port-gate integration pilots at Merak Port propose BLU-e (electronic customs and business licensing) systems integrated with ferry ticketing applications (Ferizy) to block ODOL vehicles at ticketing and boarding stages, combining digital pre-screening with physical inspection [18].

This research aims to develop a comprehensive and operational multimodal transportation policy model to reduce ODOL violations in Indonesia through systematic application of Soft Systems Methodology. Specific objectives include: (1) mapping stakeholder architecture and complex interactions in Indonesia's freight transport ecosystem; (2) identifying root definitions and CATWOE (Customers, Actors, Transformation, Weltanschauung, Owners, Environmental constraints) for ODOL enforcement systems; (3) constructing conceptual models for multimodal enforcement regimes integrating WIM technology, port-gate digital integration, and progressive sanction mechanisms; (4) comparing conceptual models with operational reality through structured comparison and stakeholder validation; (5) formulating phased implementation strategies for feasible and desirable nationwide rollout; and (6) integrating national and international regulatory standards into the policy framework. The theoretical contribution of this research lies in developing systems-based governance models for freight transportation policy in developing-country contexts, while practical contributions include actionable implementation roadmaps for achieving Indonesia's Zero ODOL targets.

## METHOD

This research adopts a qualitative-interpretive design using Soft Systems Methodology (SSM) as the primary methodological framework, supported by secondary quantitative analysis. SSM was chosen due to its effectiveness in addressing complex problems involving multiple stakeholders with divergent perspectives. The research applies a seven-stage SSM cycle, beginning with the unstructured problem situation, where a comprehensive literature review and policy document analysis provide insights into the ODOL (Over Dimensional Overloaded) issue in Indonesia. Key data sources include academic literature, regulatory documents, government reports, and industry publications, with findings explored without imposed structure to allow themes and issues to naturally emerge.

In Stage 2, a rich picture is developed to visualize the interactions within the ODOL ecosystem, capturing the roles of various stakeholders, processes, and concerns. This stage integrates findings from literature and document analysis, validated through triangulation across multiple data sources. Stage 3 formulates root definitions based on the CATWOE framework, producing different worldviews, including infrastructure protection, economic efficiency, and systems integration. These worldviews highlight the various interests and goals of stakeholders, ranging from infrastructure preservation to economic optimization and multimodal integration. Conceptual models in Stage 4 detail necessary activities for realizing the systems defined in the root definitions, focusing on governance, technology, policy development, and enforcement infrastructure.

Stage 5 compares conceptual models with real-world situations to identify gaps and constraints, highlighting issues such as ineffective coordination, lack of baseline data, and inadequate enforcement infrastructure. In Stage 6, feasible and desirable changes are identified, prioritized based on impact potential, feasibility, and stakeholder acceptance. Changes include establishing a national ODOL taskforce, deploying strategic WIM (Weigh-in-Motion) systems, and implementing multimodal transport investments. Finally, Stage 7 develops a phased implementation roadmap, structured in four phases: Governance and Diagnostics, Targeted Pilots, Scaled Enforcement, and Multimodal Integration.

The research also incorporates a thorough literature review, document analysis, and quantitative data synthesis. It triangulates findings from these sources to ensure validity and enhance the credibility of the conclusions. However, there are limitations, including the reliance on secondary data, the lack of primary data collection, and the narrow focus on national policy frameworks. The delimitations of the study include its focus on road freight and multimodal integration, excluding passenger transport or aviation freight. Additionally, while the literature used is current, it may not fully capture foundational works from earlier years.

## RESULTS AND DISCUSSION

### Rich Picture: Indonesia's ODOL Ecosystem

Systemic analysis of the ODOL problem situation in Indonesia yields a rich picture revealing complexity of stakeholder interactions, fragmented institutional structures, and multiple feedback loops perpetuating non-compliance status quo. Indonesia's ODOL ecosystem can be characterized through the following key elements:

#### 1. Stakeholder Actors and Interests

The ecosystem involves diverse actors with often conflicting interests:

- a) Ministry of Transportation as regulator with mandates for infrastructure protection and safety, yet facing pressures to support economic growth and minimize industry disruption.
- b) Police with enforcement authority but limited resources, competing priorities (traffic safety, criminal enforcement), and potential for corruption or collusion.
- c) UPPKB units as frontline enforcement with infrastructure and capacity constraints.
- d) Toll road authorities (BPJT, operators) bearing infrastructure damage costs but with limited direct enforcement powers.
- e) Port authorities managing modal transfer points with potential for enforcement integration.
- f) Transport operators (trucking companies, logistics providers) facing competitive pressures to minimize costs and maximize payloads.
- g) Vehicle owners often separate from operators and may lack direct control over loading practices.
- h) Drivers often employed or subcontracted with limited decision-making power regarding loading.

- i) Shippers and cargo owners demanding lowest transport costs and may implicitly or explicitly encourage overloading.
- j) Infrastructure managers (Ministry of Public Works, local governments) responsible for road maintenance with budgets impacted by ODOL damage.
- k) General public bearing costs through taxes, tolls, and safety risks.

## 2. Structural Elements

The regulatory framework is characterized by multiple layers (Laws, Government Regulations, Ministerial Regulations, Regional Regulations) with potential for inconsistencies and gaps. Enforcement architecture is fragmented across agencies with unclear coordination mechanisms. The infrastructure network is dominated by road transport with limited rail alternatives, creating structural dependency on trucking. The economic structure is characterized by intense competition, thin margins, and a fragmented industry with many small operators lacking resources to invest in compliance.

## 3. Process Flows

Freight movement flows predominantly via road with concentration on key corridors (North Coast Java, Trans-Sumatra, port access routes). Enforcement processes are sporadic and inconsistent, with low detection probabilities and limited follow-through on sanctions. Violation processing is delayed by bureaucratic procedures and limited digital integration. Modal transfers (road-ferry, road-rail) represent potential chokepoints for enforcement but are currently underutilized.

## 4. Key Concerns and Tensions

Infrastructure damage is accelerating with growing maintenance backlogs. Safety incidents involving overloaded vehicles generate public concern. Economic pressures on operators are intensifying with fuel costs, competition, and thin margins. Enforcement capacity is insufficient relative to violation prevalence. Coordination gaps between agencies create enforcement voids and evasion opportunities. Stakeholder resistance to strict enforcement stems from economic impacts. Technology infrastructure (WIM, digital systems) has limited coverage and capability.

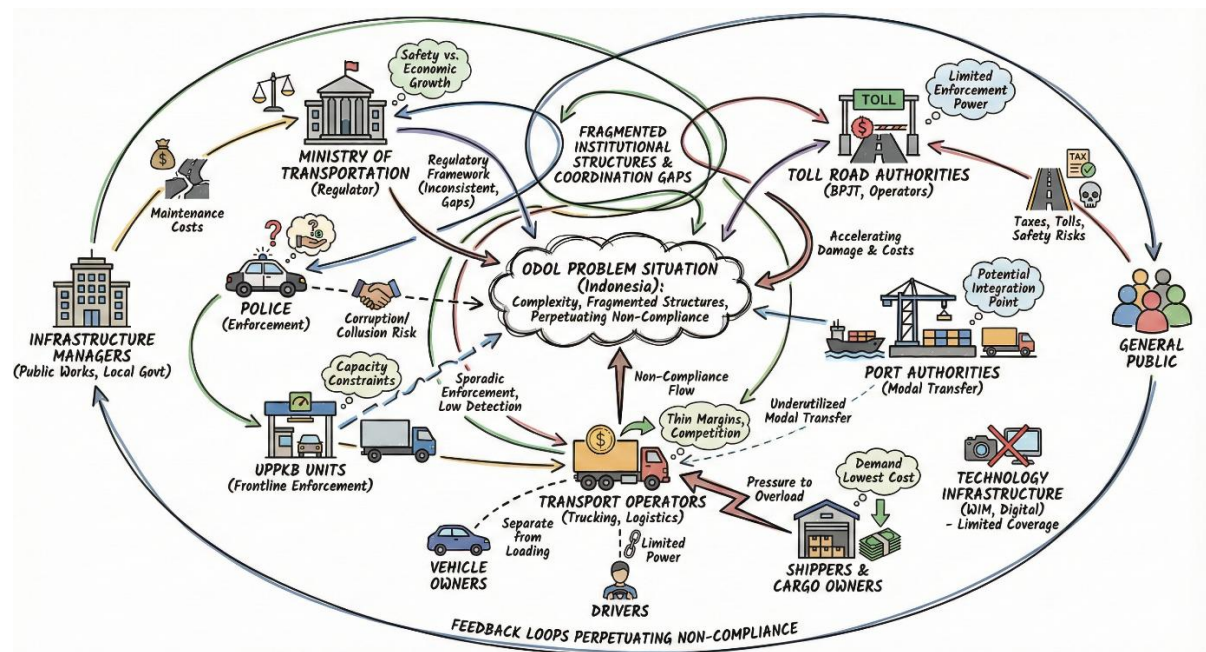


Figure 1. Rich Picture Diagram

## 5. Feedback Loops

Multiple reinforcing loops perpetuate non-compliance:

- a) Economic pressure loop – Low enforcement → overloading becomes competitive necessity → compliant operators disadvantaged → more operators overload → economic pressure intensifies
- b) Infrastructure degradation loop – ODOL → accelerated road damage → higher maintenance needs → budget constraints → delayed repairs → worse road conditions → operators overload to compensate for inefficiencies → more damage
- c) Enforcement capacity loop – High violation prevalence → enforcement resources overwhelmed → low detection probability → operators perceive low risk → more violations → resources more overwhelmed
- d) Coordination gap loop – Fragmented enforcement → operators exploit gaps → violations increase → agencies blame each other → coordination worsens → more gaps.

Rich picture analysis indicates that ODOL is not a simple compliance problem solvable through stricter enforcement alone, but rather a systemic problem requiring integrated interventions addressing economic incentives, enforcement capacity, inter-agency coordination, technology infrastructure, and modal alternatives simultaneously.

## Detailed CATWOE Analysis for ODOL Reduction System

Following the SSM framework, a comprehensive CATWOE analysis was conducted to explicate the multiple perspectives and system elements for ODOL reduction in Indonesia. CATWOE is a mnemonic representing six key elements that define a human activity system: Customers (who benefits or suffers), Actors (who performs activities), Transformation (what change occurs), Weltanschauung (worldview making the system meaningful), Owners (who has authority), and Environmental constraints (external limitations). Three distinct CATWOE analyses were developed to capture different stakeholder worldviews:

### 1. CATWOE Analysis 1 Infrastructure Protection Perspective

**Table 1. CATWOE Analysis - Infrastructure Protection Worldview**

| Element            | Description                                                                                                                                                                                                                                                                                                                                                                                                                                     | Stakeholder Implications                                                                                                                                                                           |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| C - Customers      | Indonesian public, road users, taxpayers who benefit from preserved infrastructure and reduced maintenance costs; future generations inheriting sustainable infrastructure                                                                                                                                                                                                                                                                      | Direct beneficiaries include commuters experiencing safer roads, businesses benefiting from reliable transport infrastructure, and government agencies with reduced fiscal burden for road repairs |
| A - Actors         | Ministry of Transportation (regulatory design), Police (field enforcement), UPPKB units (weighing operations), toll road operators (infrastructure monitoring), provincial transport departments (regional coordination)                                                                                                                                                                                                                        | Actors require clear mandates, adequate resources, coordinated protocols, and accountability mechanisms; current fragmentation limits effectiveness                                                |
| T - Transformation | a) Input state: Freight transport operations characterized by high ODOL prevalence (61% overload rate), fragmented enforcement, infrastructure deteriorating at accelerated rates, and economic externalities not internalized<br>b) Output state: Compliant freight operations with infrastructure-preserving loading practices, coordinated enforcement achieving high detection rates, extended pavement life, and internalized damage costs | Transformation requires systemic intervention across enforcement, technology, economic instruments, and stakeholder behavior; not achievable through enforcement alone                             |
| W - Weltanschauung | Infrastructure preservation is a paramount public interest that justifies strict                                                                                                                                                                                                                                                                                                                                                                | This worldview prioritizes long-term infrastructure sustainability over short-                                                                                                                     |

| Element                       | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Stakeholder Implications                                                                                                                                    |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                               | enforcement and sanctions; road infrastructure represents critical national asset requiring protection through regulatory compliance; overloading constitutes theft of public resources through accelerated asset depreciation                                                                                                                                                                                                                                                                                                                                              | term operator convenience; views compliance as non-negotiable public duty                                                                                   |
| O - Owners                    | Indonesian Government (through Ministry of Transportation and related agencies) holds ultimate authority to modify or terminate the system; Parliament provides legislative oversight; President/Ministers authorize major policy changes                                                                                                                                                                                                                                                                                                                                   | Ownership implies accountability for system performance and authority to allocate resources, mandate coordination, and enforce compliance                   |
| E - Environmental Constraints | a) Institutional: Limited inter-agency coordination mechanisms, bureaucratic inertia, corruption vulnerabilities<br>b) Economic: Competitive freight market with thin margins, small operator dominance, limited capital for compliance investments<br>c) Technical: Insufficient WIM infrastructure (<50 stations nationwide), paper-based data systems, limited enforcement personnel<br>d) Political: Resistance from transport industry lobby, electoral considerations affecting enforcement stringency, regional autonomy complicating national policy implementation | Constraints define feasibility boundaries for interventions; must be addressed through phased implementation, stakeholder engagement, and capacity building |

### Key Insights from Infrastructure Protection Perspective:

- Strong justification for enforcement based on quantified infrastructure damage costs (200-300% maintenance increase)
- Emphasis on technology-enabled enforcement (WIM) to overcome capacity constraints
- Progressive penalty structures calibrated to damage externalities
- Long-term perspective prioritizing sustainability over short-term economic disruption

## 2. CATWOE Analysis 2 Economic Efficiency Perspective

**Table 2. CATWOE Analysis - Economic Efficiency Worldview**

| Element            | Description                                                                                                                                                                                                                                                                  | Stakeholder Implications                                                                                                                                   |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| C - Customers      | Transport operators, trucking companies, logistics service providers who require economically viable freight operations; shippers and cargo owners demanding competitive transport costs; consumers benefiting from lower logistics costs embedded in product prices         | Economic viability of transport sector critical for supply chain functionality and price competitiveness of Indonesian products                            |
| A - Actors         | Transport company managers (operational decisions), drivers (load acceptance/rejection), vehicle owners (fleet management), logistics coordinators (route planning), industry associations (collective advocacy)                                                             | Actors operate under intense cost pressure and competitive constraints; overloading often perceived as economic necessity rather than deliberate violation |
| T - Transformation | a) Input state: High-cost, inefficient freight operations with empty backhauls, suboptimal routing, thin profit margins forcing cost-cutting through overloading, and competitive disadvantage for compliant operators.<br>b) Output state: Economically optimized transport | Transformation requires addressing root economic drivers, not just symptoms; compliance must be economically rational                                      |

| Element                       | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Stakeholder Implications                                                                                                                      |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
|                               | operations with improved load factors, efficient routing, viable profit margins without overloading necessity, and level playing field rewarding efficiency over non-compliance                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                               |
| W - Weltanschauung            | Economic survival in competitive freight market requires maximizing payload and minimizing trips; overloading is rational economic response to cost pressures and weak enforcement; strict compliance without addressing economic fundamentals threatens operator viability and employment                                                                                                                                                                                                                                                                                                                | This worldview emphasizes market realities and economic constraints; views enforcement without economic support as punitive and unsustainable |
| O - Owners                    | Transport industry (collectively through associations) owns the economic system; individual operators make autonomous decisions within market constraints; industry has power to resist, adapt, or comply with regulations                                                                                                                                                                                                                                                                                                                                                                                | Ownership implies industry must be engaged as partner, not just enforcement target; compliance requires industry buy-in                       |
| E - Environmental Constraints | a) Market: Intense price competition, shipper power in rate negotiations, fuel cost volatility, economic cycles affecting freight demand<br>b) Regulatory: Compliance costs (weighbridge fees, potential fines, time delays), regulatory complexity, inconsistent enforcement creating uneven playing field<br>c) Operational: Vehicle age and condition, driver skill levels, loading/unloading infrastructure limitations, route alternatives availability<br>d) Financial: Limited access to capital for fleet upgrades, thin margins constraining compliance investments, insurance cost implications | Constraints explain why operators overload despite knowing risks; interventions must address these economic realities                         |

#### Key Insights from Economic Efficiency Perspective:

- Overloading driven by economic necessity, not malicious intent
- Compliance requires viable economic alternatives (modal shift, efficiency improvements, fair enforcement)
- Stakeholder engagement essential to understand cost structures and design feasible policies
- Incentive programs needed alongside enforcement to make compliance economically rational

### 3. CATWOE Analysis 3 Systems Integration Perspective

**Table 3. CATWOE Analysis - Systems Integration Worldview**

| Element       | Description                                                                                                                                                                                                                                                                                                                                  | Stakeholder Implications                                                                                                                                        |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| C - Customers | Multiple stakeholders with diverse interests: infrastructure managers seeking asset preservation, operators requiring economic viability, public demanding safety and service quality, government pursuing multiple policy objectives (economic growth, infrastructure sustainability, safety, environmental protection)                     | Systems perspective recognizes legitimate interests of all stakeholders; seeks solutions creating value for multiple parties rather than zero-sum trade-offs    |
| A - Actors    | Multi-agency taskforce (Ministry of Transportation, Police, Public Works, BPJT, port authorities, provincial governments), industry representatives (operator associations, driver unions), technology providers (WIM systems, digital platforms), research institutions (monitoring and evaluation), civil society (advocacy and oversight) | Broad actor base requires coordination mechanisms, clear roles, information sharing, and collaborative decision-making; no single actor can solve problem alone |

| Element                       | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Stakeholder Implications                                                                                                                                                         |
|-------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| T - Transformation            | <p>a) Input state: Fragmented, road-centric freight system with high ODOL prevalence, uncoordinated enforcement, misaligned economic incentives, limited modal alternatives, and multiple reinforcing feedback loops perpetuating non-compliance</p> <p>b) Output state: Integrated multimodal freight system with balanced modal shares, coordinated multi-agency enforcement, aligned economic incentives, viable rail/ferry alternatives, and compliance-conducive ecosystem where all stakeholders benefit from sustainable operations</p>                                                                                     | Transformation is systemic, requiring simultaneous interventions across multiple domains; sequential single-domain interventions insufficient                                    |
| W - Weltanschauung            | Systemic integration and stakeholder coordination can simultaneously achieve infrastructure preservation, economic efficiency, safety, and environmental sustainability; ODOL is symptom of systemic dysfunction, not isolated problem; solutions require addressing root causes (economic pressures, enforcement gaps, modal imbalances, coordination failures) rather than symptoms                                                                                                                                                                                                                                              | This worldview emphasizes holistic thinking, multiple causation, feedback loops, and leverage points; rejects simplistic single-cause explanations or single-solution approaches |
| O - Owners                    | National Government (collective ownership across ministries) with President/Cabinet as ultimate authority; Parliament providing legislative framework and oversight; Provincial governments with implementation authority; stakeholders collectively owning system success through participation                                                                                                                                                                                                                                                                                                                                   | Distributed ownership requires governance architecture (National ODOL Taskforce) to coordinate authorities, align objectives, and ensure accountability                          |
| E - Environmental Constraints | <p>a) Systemic: Path dependencies (historical road dominance), institutional inertia, sunk investments in road infrastructure</p> <p>b) Geographic: Archipelagic geography necessitating multimodal solutions, varied terrain affecting transport costs, regional disparities in enforcement capacity</p> <p>c) Developmental: Infrastructure investment competing with other priorities, fiscal constraints limiting simultaneous investments, capacity building timelines</p> <p>d) Global: International trade patterns, ASEAN harmonization requirements, technology transfer dependencies, development partner conditions</p> | Constraints require phased implementation, prioritization of high-impact interventions, leveraging of existing infrastructure, and adaptive management                           |

#### Key Insights from Systems Integration Perspective:

- ODOL is systemic problem requiring integrated solutions across enforcement, economics, infrastructure, and governance
- Multiple feedback loops (economic pressure, infrastructure degradation, enforcement capacity, coordination gaps) reinforce non-compliance
- Leverage points exist at governance architecture (coordination), technology deployment (WIM), economic instruments (progressive penalties + incentives), and modal alternatives (rail investment)
- Sustainable solutions require stakeholder engagement, phased implementation, and adaptive management

## 4. Comparative Analysis Across Worldviews

**Table 4. Comparison of CATWOE Worldviews**

| Dimension            | Infrastructure Protection                  | Economic Efficiency                    | Systems Integration                              |
|----------------------|--------------------------------------------|----------------------------------------|--------------------------------------------------|
| Primary Objective    | Infrastructure preservation                | Operator viability                     | Multiple objectives balance                      |
| Problem Framing      | Non-compliance threatening assets          | Economic pressures forcing overloading | Systemic dysfunction                             |
| Solution Emphasis    | Strict enforcement + technology            | Economic alternatives + incentives     | Integrated multi-domain interventions            |
| Stakeholder Approach | Government-led regulation                  | Industry partnership                   | Multi-stakeholder collaboration                  |
| Implementation Logic | Command-and-control                        | Market-based                           | Adaptive governance                              |
| Success Metrics      | Compliance rates, infrastructure condition | Operator profitability, employment     | System performance across multiple dimensions    |
| Risk Assessment      | Under-enforcement perpetuating damage      | Over-enforcement threatening viability | Fragmented implementation limiting effectiveness |

### Synthesis and Integration

The synthesis of the three CATWOE analyses reveals key tensions and complementarities in the design of ODOL policies. One significant tension exists between enforcement and economics: the infrastructure protection worldview advocates for strict enforcement to preserve infrastructure, while the economic efficiency perspective emphasizes the constraints faced by operators in complying with these regulations. The resolution to this tension lies in developing a balanced approach that combines calibrated enforcement with economic support mechanisms, such as incentives, modal alternatives, and efficiency improvements. Additionally, there is a complementarity between technology and coordination; while all perspectives acknowledge the importance of technology, particularly Weigh-in-Motion (WIM) systems integration viewpoint stresses that technology alone is insufficient without strong governance coordination and stakeholder engagement.

The research adopts the systems integration worldview as the primary framework because it accommodates the legitimate interests of all stakeholders, addresses the root causes of ODOL issues, and offers a conceptual foundation for integrated interventions. This perspective enables the identification of key leverage points for systemic change and facilitates stakeholder engagement by acknowledging and addressing diverse viewpoints. However, insights from the infrastructure protection worldview, such as the need for enforcement and damage quantification, and from the economic efficiency perspective, including operator constraints and incentive design, are integrated into the comprehensive policy model. This approach ensures a holistic solution to the ODOL problem, balancing enforcement, economic viability, and systemic integration for sustainable policy outcomes.

### Conceptual Model: Integrated Multimodal ODOL Reduction System

The conceptual model for an integrated multimodal ODOL reduction system is structured into four interrelated subsystems. Subsystem 1, Governance and Coordination Architecture, focuses on establishing a clear governance structure by forming a National ODOL Taskforce with representatives from key agencies. This taskforce will be empowered with decision-making authority and accountability mechanisms. It will also develop inter-agency Memoranda of Understanding (MOUs) to outline roles, responsibilities, and protocols. An integrated data platform will facilitate sharing enforcement data, WIM measurements, and infrastructure condition information. Stakeholder engagement mechanisms, such as

consultation forums and feedback channels, will ensure policy refinement is based on input from all relevant parties. This subsystem aims to address coordination gaps and build institutional capacity for long-term policy implementation.

Subsystems 2, 3, and 4 focus on enhancing enforcement, incentivizing compliance, and providing multimodal alternatives. Subsystem 2, Evidence-Based Enforcement Infrastructure, enhances enforcement capabilities using technology and data-driven strategies, including WIM system deployment, port-gate digital integration, tollgate authorization, and mobile enforcement. A risk-based enforcement targeting system will ensure comprehensive coverage and minimize evasion. Subsystem 3, Calibrated Sanction and Incentive Mechanisms, aligns transport operator incentives with compliance by introducing progressive penalty structures and compliance incentives, such as reduced inspection frequencies and priority lane access. A revenue recycling mechanism will reinvest penalty revenues into enforcement and infrastructure. Subsystem 4, Multimodal Integration and Alternatives, aims to reduce road freight dependency by investing in rail freight corridors, developing multimodal freight hubs, and introducing policy incentives for modal shifts. This subsystem addresses the structural causes of ODOL violations by creating sustainable alternatives to overloading, ensuring long-term compliance.

### **Structured Comparison: Conceptual Model vs. Current Reality**

The structured comparison between the conceptual model and current reality reveals several critical gaps that explain the persistent ODOL issues and highlight priority intervention areas. In terms of governance architecture, the conceptual model calls for an integrated National ODOL Taskforce with clear coordination, but the current system is fragmented, with no central body to resolve conflicts or coordinate efforts. This fragmentation leads to enforcement gaps and regional inconsistencies, emphasizing the need for a cohesive governance structure. Regarding enforcement infrastructure, the conceptual model envisions comprehensive WIM coverage and integrated systems, but in reality, WIM stations are limited, weighbridges are manual, and there is no systematic integration at ports or tollgates. This points to the need for significant infrastructure investment, starting with high-priority locations. Similarly, while the model proposes progressive penalties based on damage costs and violation history, current penalties are often fixed, low, and ineffective at deterring violations, highlighting the need for sanction reforms.

Further gaps are identified in technology and data systems, where the conceptual model requires integrated data platforms and analytics, but current systems are paper-based with limited data sharing and analytics capacity. The implication is that a digital transformation is essential to improve enforcement and data management. In stakeholder engagement, the model emphasizes systematic consultation and co-design, whereas current policies are often top-down, leading to resistance from stakeholders. Institutionalizing engagement is necessary for policy feasibility and consensus building. The model also includes modal shift incentives and rail development, but rail infrastructure remains underutilized, with over 90% of freight moving by road. This highlights the need for long-term multimodal infrastructure investments. Finally, while the model stresses continuous monitoring and adaptive policy adaptation, current monitoring systems are limited, with evaluations being sporadic. Establishing robust monitoring and adaptive management frameworks is critical to ensure that policies remain effective and responsive to changing conditions.

### **Phased Implementation Strategy**

This research proposes a four-phase implementation strategy for reducing ODOL violations in Indonesia, aiming to build capabilities progressively and scale successful approaches nationally over a 10-year period. Phase 1 focuses on governance establishment and baseline diagnostics, with key activities including the creation of a National ODOL Taskforce, stakeholder mapping, baseline WIM monitoring, and a comprehensive situation analysis to inform policy design. In Phase 2, targeted enforcement pilots and port integration will test enforcement operations, WIM systems, and digital integration at ferry terminals. The results from these pilots will be rigorously evaluated to refine approaches before scaling. Phase 3 focuses on expanding proven enforcement strategies, optimizing sanctions, and building enforcement capacity, with nationwide WIM deployment, tollgate integration, and an integrated digital platform for real-time data sharing. Finally, Phase 4 addresses structural factors through multimodal integration, rail corridor development, modal shift incentives, and industry restructuring to reduce road freight dependency and achieve sustainable long-term compliance.

The phased implementation is structured to adapt based on lessons learned from earlier phases, ensuring continuous improvement and refinement. Investment in multimodal infrastructure, such as rail corridors and multimodal hubs, will support the transition away from over-reliance on road transport. A focus on compliance incentives, including reduced inspection frequencies and recognition programs, will encourage voluntary compliance among operators. To ensure financial sustainability, revenue from penalties will be reinvested into enforcement and infrastructure development. By addressing both enforcement and structural challenges, this strategy aims to create a robust and adaptive policy system for ODOL reduction, supported by comprehensive data collection, stakeholder engagement, and international best practices [12][40][47][48][52][53].

### **Implementation Governance and Resource Requirements:**

The implementation governance and resource requirements for the ODOL reduction strategy are structured to ensure effective coordination, adequate funding, and risk mitigation. The National ODOL Taskforce will oversee the implementation across all phases, with phase-specific working groups focusing on detailed execution. The estimated total investment over a 10-year period is between USD 500-800 million, allocated across enforcement infrastructure (USD 200-300M), digital systems (USD 50-100M), capacity building (USD 50-100M), and multimodal infrastructure (USD 200-400M). Funding will be sourced from national budget allocations, toll road revenues, penalty revenues recycled into enforcement, and potential development bank financing. The phased approach provides flexibility to adapt to fiscal constraints, changing priorities, and implementation experiences, allowing for adjustments in the timeline. This strategy also reduces risks through pilot projects that facilitate learning, refining approaches, and build stakeholder support progressively before committing to larger-scale investments.

### **Integration of National and International Standards**

The implementation of the multimodal policy model for ODOL reduction must comply with national standards and align with international best practices to ensure legal validity, technical adequacy, and regional harmonization. The policy model fully aligns with Law Number 14 of 2024 on Road Traffic and Transportation, which provides the legal foundation for vehicle dimension and weight regulations, enforcement authorities, and sanction mechanisms [5]. The proposed progressive penalty structures are designed to work within the existing legal framework, although regulatory amendments may be required to explicitly authorize damage-based penalty calibration. The Ministry of Transportation's specifications on GVW, dimension standards, and UPPKB operations are incorporated as

technical baselines for enforcement systems [6]. Additionally, regional regulations (Perda) are considered, with recommendations for harmonization to prevent regulatory fragmentation and arbitrage opportunities. The model also takes into account the ASEAN Framework Agreement on the Facilitation of Goods in Transit (AFAFGIT) and the ASEAN Framework Agreement on Multimodal Transport (AFAMT), ensuring compatibility with regional standards and facilitating cross-border freight movement [29][42][43].

Furthermore, the model draws on the EU Directive 96/53/EC (amended 2015/719) on vehicle weights and dimensions to provide an advanced enforcement model, adapting key elements for the Indonesian context. These include technology-enabled enforcement, cross-border information sharing, risk-based enforcement, and progressive sanctions [30]. The World Bank's infrastructure guidelines inform the quantification of infrastructure damage costs and penalty calibration, ensuring that penalties are economically grounded [31][41]. The IRF's best practices and World Road Statistics offer comparative benchmarks to refine enforcement strategies and compliance programs [31]. The model also ensures technical standards compliance by aligning WIM technology specifications with international standards such as ASTM E1318 and COST 323. Digital integration systems follow international data exchange standards, ensuring interoperability and futureproofing. To maintain alignment with evolving standards, the National ODOL Taskforce will track international regulatory developments and recommend policy updates, ensuring continuous improvement and adaptation.

## CONCLUSION

This research has developed a comprehensive multimodal transportation policy model to address Over Dimension Over Load (ODOL) violations in Indonesia through the systematic application of Soft Systems Methodology (SSM). The analysis shows that the ODOL issue is systemic, with complex stakeholder interactions, fragmented institutions, limited enforcement capacity, misaligned economic incentives, and heavy reliance on road freight transport. Traditional command-and-control approaches have proven ineffective as they fail to address the root causes and systemic dynamics that perpetuate non-compliance. The policy model integrates four key subsystems: governance and coordination, evidence-based enforcement infrastructure, calibrated sanctions and incentives, and multimodal integration, aiming to tackle these challenges comprehensively.

The proposed implementation strategy is phased, starting with building institutional capacity, conducting targeted pilots, and gradually scaling successful approaches over a 10-year horizon. The model emphasizes that reducing ODOL violations requires not only stronger enforcement but also structural transformation through multimodal investments, professionalization of the industry, and reforms to create long-term compliance incentives. The model aligns with national regulations and international frameworks, ensuring legal and technical adequacy. Theoretical contributions include advancing systems-based governance frameworks for transportation policy, while practical contributions offer a clear roadmap for policymakers, outlining specific actions, timelines, and expected outcomes for each phase of implementation.

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