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ENABLING REGULATION AND THE ALIGNMENT OF REGULATORY MECHANISMS TO ACCOMMODATE TECHNOLOGICAL CHANGE

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ABSTRACT

Regulatory mechanisms can drift out of alignment with contemporary technologies and administrative capacities, generating frictions that raise costs, increase uncertainty, and narrow the range of activities that remain economically viable. This paper develops a generalizable account of enabling regulation as a strategy for reducing these frictions while preserving the social outcomes a regime is designed to protect or promote. A microeconomic model specifies how compliance costs, administrative burdens, uncertainty, and information asymmetries shape decisions to enter and operate within regulated activity and identifies the channels through which targeted reforms to regulatory mechanisms expand the set of economically viable activities. Three cases from the U.S. Department of Transportation show how agencies diagnose regulatory lag and implement reforms that restore alignment by modernizing pathways, updating classifications, improving information systems, and strengthening coordination. These findings clarify the economic logic of enabling regulation and show how targeted reforms to regulatory mechanisms can reduce frictions in domains where technological change outpaces existing frameworks.

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Established in 2009, the GW Regulatory Studies Center is an academic center of the George Washington University and its Trachtenberg School of Public Policy and Public Administration. The Center's mission is to improve regulatory policy through research, education, and outreach. The Center is a leading source for applied scholarship in regulatory issues, and a training ground for anyone who wants to understand the effects of regulation and ensure that regulatory policies are designed in the public interest.

I. Introduction

Regulatory regimes shape economic activity by defining the costs, risks, and informational conditions under which firms and individuals operate. When a regime's operational features are not aligned with prevailing technologies and institutional arrangements, the resulting misalignment can cause the regime to impose more constraint than is necessary to achieve its intended social outcomes. This misalignment generates frictions, which take the form of compliance costs and administrative requirements that exceed what is necessary to internalize relevant externalities or correct underlying market failures. As these frictions accumulate, they make entry into economic activity less attainable. Restricted entry reduces output and slows the diffusion of welfare enhancing technologies and practices. These dynamics create a need for strategies that restore alignment between the design of the regime and contemporary technological and institutional conditions.

One such strategy is enabling regulation, an approach that modernizes pathways, categories, and compliance structures without reopening or renegotiating a regime's substantive aims. It reduces frictions by updating misaligned elements of the regime, lowering compliance and administrative costs, reducing uncertainty about regulatory expectations, and improving information flows. It also targets the subset of what Sunstein (2019) characterizes as regulatory sludge that should be reduced or removed, distinguishing these unjustified burdens from the frictions that continue to serve a regulatory purpose. Although the regime's substantive aims could be reconsidered as technologies and risk profiles evolve, doing so requires reopening the underlying risk and policy determinations, which broadens the scope of the decision and slows the implementation of needed reforms. Under these institutional constraints, enabling regulation reflects a second best approach in which agencies reduce mechanism induced costs when revisiting the objective would introduce delay and uncertainty and restricted participation imposes real social costs.

This paper develops the microeconomic foundations of enabling regulation and specifies the channels through which regulatory design affects decisions to enter and participate in regulated activity. The analysis focuses on how the structures of a regulatory regime interact with technological and administrative conditions to generate or reduce frictions. Scholarship in law, economics, and public administration has examined regulatory design, administrative burdens, and innovation oriented governance, but the channels through which regulatory interventions reduce frictions remain implicit. The contribution of this paper is to show how the operational mechanisms of a regulatory regime determine the cost structure actors face and, in turn, shape participation. Participation changes represent the first order response to shifts in this mechanism induced cost structure and therefore provide the earliest signal of whether alignment has been restored. This account clarifies how frictions accumulate, how they restrict participation, and how targeted interventions restore alignment.

The U.S. Department of Transportation (DOT) provides a natural setting for examining these dynamics. DOT's regulatory regimes were developed for technological eras centered on crewed aviation, human-operated motor vehicles, and conventional rail systems. As technologies and markets evolve, these regimes accumulate frictions that make misalignment visible. This paper examines three cases: the Federal Aviation Administration's Part 107 rule for small unmanned aircraft systems, the Federal Railroad Administration's Tier III passenger equipment standards, and the National Highway Traffic Safety Administration's modernization of electronic odometer disclosures. The cases show how enabling regulation reduces frictions, clarifies compliance pathways, and shapes participation across diverse regulatory contexts. DOT's regulatory diversity makes it an analytically rich environment for observing how reforms to the operational features of a regime perform across different technological and institutional settings and for assessing where this approach is most effectively applied.

This paper first reviews the literature on regulatory adaptation to identify the broad families of tools and institutional processes available for governing technological change. It then develops a conceptual framework grounded in a microeconomic model of participation in which compliance costs, administrative burdens, uncertainty, and information asymmetries shape decisions to enter and operate within a regulated market. The framework is applied to three DOT rules to show how misaligned regulatory structures generate distinct frictions and how targeted reforms reduce them. The paper then identifies the strategic instruments that generalize across the cases and draws implications for how regulatory structures can be aligned with contemporary technological and institutional conditions in ways that reduce frictions and support broader participation.

II. Literature Review: Regulatory Design, Administrative Capacity, and Friction-Reducing Approaches

Regulatory scholarship spans diverse traditions that examine how rules shape economic behavior, institutional performance, and technological change. Existing work identifies families of regulatory instruments, highlights the role of administrative capacity, and explores adaptive and experimentalist approaches. This study builds on these contributions by specifying how regulatory design alters compliance costs, administrative burdens, uncertainty, and information asymmetries, the factors that shape the cost components governing participation. This section synthesizes these strands of research to clarify the conceptual and empirical foundations for understanding how enabling regulation reduces frictions.

A first strand of scholarship examines how regulatory design structures the economic environment in which firms and individuals make decisions. Foundational work emphasizes aligning regulatory tools with policy problems, institutional context, and implementation capacity (Baldwin, Cave, and Lodge 2012; Balla and Lodge 2011; Decker 2014). Classic classifications distinguish between prescriptive, performance-based, market-based, and informational approaches (Gunningham and Sinclair 1999; Sunstein 2013). The classic

frameworks motivate a more precise account of how specific instruments alter the cost components that shape participation, including compliance costs, administrative burdens, and uncertainty. In the next section, the model formalizes these cost shaping mechanisms and specifies how they influence decisions to participate in regulated activity.

A second strand focuses on the administrative and organizational conditions that shape regulatory performance. Research on bureaucratic capacity highlights how expertise, resources, and procedural flexibility influence the feasibility of implementing complex or adaptive regulatory strategies (Carpenter 2001; Coglianese 2012; Coglianese 2016a; OECD 2020). Work on administrative burdens shows how learning, compliance, and psychological costs can impose substantial burdens on regulated actors (Moynihan, Herd, and Harvey 2015; Moynihan and Soss 2014). Empirical studies of regulatory cost estimation demonstrate that administrative processes often generate unanticipated or underestimated burdens (Harrington, Morgenstern, and Nelson 2000). These insights underscore why information and administrative infrastructure, and the institutional capacity to operate them, are central to reducing frictions.

A third body of literature examines innovation oriented, adaptive, and experimentalist approaches to regulation. Scholars analyze how regulatory systems can accommodate uncertainty, support experimentation, and adjust to evolving technologies and practices (Black 2005; Bennear and Wiener 2019; Craig and Ruhl 2014; McCray, Oye, and Petersen 2010). Frameworks such as responsive regulation, smart regulation, and experimentalist governance emphasize procedural flexibility, iterative learning, and risk tiering (Sabel and Zeitlin 2012). Research on regulatory excellence identifies organizational characteristics such as learning, responsiveness, and continuous improvement as core drivers of high performing systems (Coglianese 2016b). Related debates about permissionless innovation (Thierer 2014) and responsible innovation (Floridi and Cowls 2019; OECD 2019) highlight the tension between precautionary and enabling approaches. This work identifies the importance of flexible compliance pathways and risk-responsive oversight, which later appear as key friction reducing instruments. However, it does not specify the channels through which such flexibility reduces frictions.

A fourth and increasingly important contribution comes from systematic evidence on how regulatory frameworks affect sectoral performance. Mishra and Kumar's 2023 cross sector review synthesizes fifty-one empirical studies across telecommunications, energy, finance, water, transportation, and other industries. Their analysis demonstrates consistent associations between regulatory quality, institutional capacity, and sectoral outcomes, and identifies common mechanisms such as investment incentives, transaction costs, information asymmetries, and governance structures. They show that regulatory frameworks shape performance through both structural features, such as independence and competition policy, and administrative processes related to oversight, enforcement, and procedural design. These findings point to the role of coordination and institutional alignment in shaping regulatory outcomes and highlight a

persistent gap. Empirical studies document outcomes but rarely formalize the mechanisms through which regulatory frictions accumulate or are reduced.

Recent work extends these insights by examining how regulatory systems adapt to technological and administrative change. Research on regulatory foresight emphasizes the importance of iterative updating and structured learning as technologies evolve (Bennett Moses 2003). Studies of digital regulatory governance show how standardized data formats, digital reporting structures, and algorithmic tools reduce administrative burdens and improve the reliability of regulatory information (Coglianese and Lehr 2017). Work on institutional coordination similarly underscores the role of coherent legal frameworks and interoperable administrative processes in reducing frictions and supporting system performance (Gilad 2010). These strands converge on the idea that regulatory performance depends on the alignment of regulatory structures with technological and administrative realities.

Collectively, these strands identify broad families of regulatory tools and institutional processes but do not specify the channels through which such tools reduce frictions. The microeconomic framework developed in Section 3 formalizes these channels by modeling how mechanism induced costs shape decisions to participate in regulated economic activity. It explains how regulatory lag arises when regulatory structures become misaligned with contemporary technologies or administrative capacities and why targeted reforms reduce accumulated frictions and expand participation.

III. Microeconomic Model of Participation and Frictions

A microeconomic perspective on participation provides the conceptual foundation for the model developed in this section. This perspective examines how compliance costs, administrative burdens, uncertainty, and information asymmetries shape decisions to enter and operate within a regulated market. These cost-shaping mechanisms are the channels through which regulatory frictions suppress activity and through which targeted reforms that reduce those frictions influence participation. Enabling regulation is a set of reforms that responds to a regime that has become restrictive, outdated, or poorly aligned with contemporary technologies, a condition often described as regulatory lag. It addresses this misalignment by reducing accumulated frictions and enabling feasible pathways within the existing regulatory structure.

Participation in regulated economic activity R occurs when the expected net benefit to a regulated actor is non-negative. Let $E[B_i]$ denote the expected benefit to representative actor i, $E[C_i]$ the expected cost, and $E[\pi_i]$ the resulting expected net benefit:

$$E[\pi_i] = E[B_i] - E[C_i] \geq 0 \quad (1)$$

The expected cost of participation can be decomposed into four components:

$$E[C_i] = F_i + V_i + A_i + \theta_i \quad (2)$$

where F_i represents compliance costs, V_i variable operating costs, A_i administrative and procedural burdens, and θ_i the cost of regulatory uncertainty. Regulatory frictions refer specifically to costs created by the regulatory regime: F_i, A_i, and θ_i. When frictions are high, actors may choose not to enter or continue participating in economic activity even when the underlying technology or business model is viable. Variable operating costs V_i reflect the cost of production and therefore fall outside the category of regulatory frictions. Information asymmetries affect frictions through their effects on A_i and θ_i and do not constitute a separate cost component.

The model treats as exogenous the substantive outcome the regime is designed to protect or promote, formalized here as the regulatory objective. Such objectives define the safety, consumer protection, environmental performance, financial integrity, or market conditions the regime seeks to secure. The framework also treats as exogenous the technological and production environment, demand, the legacy design, and the institutional and infrastructure conditions in place at the time of reform, even though these may evolve as reforms are implemented. It likewise treats as exogenous the evidentiary means through which compliance with the objective is ordinarily demonstrated, because these means are part of the existing regulatory structure rather than created by the reform process.

The model assumes agencies have discretion over the mechanisms used to achieve their regulatory objectives. Let M denote the mechanism used to achieve a regulatory objective. A regulatory mechanism induces a vector of costs:

$$C_i(M) = (F_i(M), A_i(M), \theta_i(M)) \quad (3)$$

A potential source of friction is regulatory lag, the misalignment that can occur when existing regulatory structures no longer reflect contemporary technologies, risk profiles, or institutional capacities. Regulatory lag occurs when a legacy structure imposes higher mechanism-induced costs than an available alternative that would achieve the same regulatory objective under current conditions for a non-empty set of actors:

$$C_i(M_{\text{legacy}}) > C_i(M_{\text{aligned}}) \quad (4)$$

This increase in mechanism induced costs contracts the participation set:

$$P(M_{\text{legacy}}) \subset P(M_{\text{aligned}}) \quad (5)$$

where the participation set $P(M)$ is defined as:

$$P(M) = \{i: E[B_i] - E[C_i(M)] \geq 0\} \quad (6)$$

Regulatory lag therefore reflects a mechanism–objective misalignment. The objective remains unchanged, but the means of achieving it have become outdated. The resulting frictions restrict participation by imposing costs beyond those required to internalize relevant externalities or correct any underlying market failure, burdens that do not advance the regulatory objective.

Enabling regulation reduces frictions through interventions that preserve the regulatory objective while reducing mechanism induced costs. A mechanism change from M_{legacy} to M_{aligned} constitutes enabling regulation if it preserves the objective and reduces mechanism induced costs for at least one actor outside the legacy participation set. Formally, enabling regulation requires that

$$E\left[C_i\left(M_{\text{aligned}}\right)\right] < E\left[C_i\left(M_{\text{legacy}}\right)\right] \text{ for some } i \notin P\left(M_{\text{legacy}}\right) \tag{7}$$

The intervention expands the set of economic actors for which participation is feasible by lowering compliance costs, administrative burdens, or uncertainty.

Treating the regulatory objective as fixed clarifies the scope of the participation model and the constraints regulators face when adopting enabling reforms. The participation model characterizes how mechanism-induced frictions shape decisions by regulated actors, but regulators face their own constraints that limit when enabling reforms can be adopted. Regulators must be able to justify, based on available information and analysis, that a modernized mechanism is expected to satisfy the established regulatory objective. The evidentiary means for demonstrating that the objective is met are part of the existing regulatory structure and uncertainty in these means can limit what regulators can credibly conclude. When uncertainty about risks, technologies, or actor behavior is substantial, a regulator may be unable to make this judgment, and retaining a more restrictive mechanism reflects the limits of available information rather than a failure to recognize the costs of misalignment. Treating the regulatory objective as fixed confines the problem to determining whether a modernized mechanism can achieve the established purpose. When a mechanism cannot be modernized while maintaining the objective, the frictions at issue may reflect the substantive structure required to meet it, placing the problem outside the tractable domain of enabling regulation.

While treating the objective as fixed contains the scope of the problem for regulators, this perspective does not rule out broader social implications that arise through participation effects. Because participation conditions determine which actors can operate, changes in participation have consequences that extend beyond the regulatory objective itself and shape the competitive environment in which regulated activity occurs. Restricted participation limits entry to actors able to absorb high frictions, allowing incumbents to exercise greater market power and weakening incentives for efficiency and innovation. While the participation effect is the first order outcome of changes in the magnitude of mechanism induced frictions, it also reflects changes in broader social costs because it is the channel through which the regime generates

them. Participation effects therefore provide the model's metric for evaluating the performance of enabling regulation.

Finally, the model provides a structure for identifying the economic linkages through which specific interventions reduce frictions and a rationale for incorporating them into strategies for managing technological progress within a regime. Enabling regulation reduces frictions through four channels that shape whether participation in regulated activity is economically feasible. It reduces compliance costs by lowering the resources required to enter, comply, or demonstrate eligibility; reduces administrative burdens by decreasing procedural and process related costs; reduces uncertainty by clarifying expectations and making compliance pathways more predictable; and improves information flows by increasing the quality, comparability, and accessibility of information. These four channels provide the causal structure for the empirical analysis that follows. Section 4 examines how specific DOT rules generate and reduce these frictions and how participation responds when mechanism induced costs change. Section 5 then identifies the strategic instruments regulators use to update the mechanisms that create these frictions and shows how those instruments operate across different forms of regulatory lag.

IV. Enabling Regulation and the Reduction of Regulatory Frictions

This section applies the friction based framework to three DOT rules, illustrating how frictions arise and accumulate and how targeted reforms reduce them. The cases are intentionally concise. Detailed regulatory histories and technical documentation are presented in Appendix A. The analysis proceeds by identifying the forms of misalignment that generate these frictions.

Regulatory lag takes several forms depending on the source of the misalignment between existing regulatory structures and contemporary technologies or administrative capacities. Technological lag arises when the conditions for demonstrating compliance are built around the capabilities and risk assumptions of an earlier technology. Engineering lag occurs when the technical performance requirements embedded in the regulatory structure are built around older engineering designs and therefore no longer match contemporary technologies or engineering practices. Administrative lag emerges when the administrative and information processing structures that govern how compliance is executed are built around outdated workflows and therefore no longer match contemporary digital administrative capacities.

a. Part 107: Enabling Small UAS Operations Through Updated Classification and Risk-Aligned Approval Pathways

Part 107 illustrates technological regulatory lag as the primary misalignment, because the conditions for demonstrating compliance were built around the capabilities and risk assumptions of crewed aviation rather than small UAS. Before 2016, commercial UAS operations were governed by approval structures that no longer matched their operational characteristics or risk

profile, while the legacy system introduced administrative lag through burdensome, individualized authorizations and discretionary evidentiary judgments. The framework also exhibited elements of technological lag through outdated operational categories and administrative lag through approval pathways that relied on case specific assessments.

Pre-Part 107, commercial UAS operators were required to obtain case-by-case exemptions under Section 333 of the FAA Modernization and Reform Act of 2012. Approvals involved individualized petitions, manual reviews, and discretionary judgments, creating substantial administrative burdens. Evidentiary expectations were unclear, processing times varied widely, and approval outcomes were unpredictable. These conditions reflected underlying information asymmetries: regulators lacked standardized information about operator capabilities, and operators lacked clarity about acceptable demonstrations of risk.

Firms increasingly viewed the legacy system as a barrier to domestic experimentation, and many shifted early testing and development activities overseas, where regulatory environments were more permissive. These constraints suppressed a large latent market for small UAS applications such as aerial photography, inspection, and agricultural monitoring. Congressional direction in the FAA Modernization and Reform Act of 2012 also exerted pressure on FAA to update its approval processes (FAA 2016).

Part 107 reduced these frictions through structural reforms that modernized entry, classification, and approval pathways. The rule created a dedicated small UAS category and established the Remote Pilot Certificate as a standardized entry requirement (FAA 2016). It replaced individualized exemptions with predictable, rule-based pathways and introduced a structured waiver process with clear evidentiary expectations (FAA 2016). Part 107 also modernized the legacy Certificate of Waiver or Authorization (COA) process for routine small UAS operations, which had required operation-specific reviews and produced inconsistent processing times. Standardized electronic workflows reduced administrative burdens and made review outcomes more predictable.

Participation expanded rapidly once these frictions were reduced. FAA's regulatory evaluation anticipated these effects, projecting that standardized entry pathways would substantially increase the number of commercial small UAS operators once administrative burdens and evidentiary uncertainty were reduced (Miner, Thurston, and Wharff 2016). Remote Pilot Certificates increased from a few thousand exemptions under the legacy regime to more than 100,000 within two years. Today, FAA reports nearly 428,000 certificated Remote Pilots (FAA 2025).

FAA retained the existing safety objective throughout the reform process, noting in the final rule that Part 107 maintains the established level of safety. The agency declined to relax that objective because the evidence base did not yet support expanded operations such as flights over people, night operations, or beyond visual line of sight operations (FAA 2016).

The Part 107 structured waiver process functioned as an initial enabling mechanism by creating a predictable pathway for operations not yet incorporated into the rule. As participation expanded, the data generated through standardized operations and waivers supplied FAA with the empirical foundation needed to develop follow-on rules such as Operations Over People (FAA 2021) and Remote ID (FAA 2021b). Although the Part 107 waiver process enabled many operations by providing a structured, criteria-driven pathway, some frontier applications, most notably beyond-visual-line-of-sight operations, remain dependent on individualized approvals (FAA 2022). These follow-on rules extend the same enabling logic by converting individualized approvals into standardized, risk-aligned pathways that preserve the safety objective while reducing costs and uncertainty. In that sense, Part 107 established a durable regulatory architecture that FAA has continued to extend through successive rulemakings.

b. FRA Tier III: Enabling High-Speed Trainset Adoption Through Performance-Based Engineering Standards

Tier III illustrates engineering regulatory lag as the primary misalignment, because the technical performance requirements embedded in FRA's passenger equipment standards were built around older engineering designs that no longer matched contemporary high-speed rail technologies. Before the rule, trainsets operating above 125 mph were governed by prescriptive, strength-based crashworthiness standards that did not reflect modern crash energy management techniques. The legacy framework also exhibited elements of technological lag through outdated equipment classifications and administrative lag through approval pathways that relied on individualized waivers and case-specific analyses.

Before Tier III, FRA's passenger equipment standards rested on tests of rigid carbody strength rather than modern crash energy management techniques. These standards were designed for conventional U.S. rail operations characterized by heavy equipment, relatively low-frequency service, and limited interoperability with freight traffic. Modern international trainsets could not be deployed in the United States without costly redesign or individualized waivers, and manufacturers lacked clarity about the analyses and tests required for approval (FRA 2018).

Tier III reduced these frictions by creating a dedicated regulatory category for high-speed trainsets and establishing a performance-based crashworthiness framework. The new category aligned U.S. treatment of high-speed equipment with contemporary international practice, reducing redesign burdens by allowing manufacturers to rely on validated crash energy management pathways rather than retrofitting designs to meet prescriptive buff-strength requirements. The rule clarified evidentiary expectations by specifying the modeling evidence, dynamic tests, and engineering analyses that could demonstrate compliance (FRA 2018). These reforms reduced compliance costs by eliminating unnecessary redesigns, lowered uncertainty by clarifying acceptable performance thresholds, and reduced information asymmetries by articulating the engineering evidence required for approval.

Participation effects remain prospective because no Tier III trainsets have yet been deployed in the United States. California is the only project that has advanced to the stage where Tier III equipment decisions are relevant. The project is entering track construction and targeting initial service in the early 2030s but has not procured equipment, a pattern that reflects the sequencing and financing of large-scale infrastructure rather than equipment standards alone (California High-Speed Rail Authority, 2025). Other proposed projects have not progressed to the point where equipment procurement is relevant. In Florida, the Tampa–Orlando high-speed rail project was canceled before infrastructure construction, and Brightline operates at Tier I speeds with Tier I-compliant equipment, so neither involved Tier III trainsets or Tier III regulatory approvals (U.S. Department of Transportation, Federal Railroad Administration, 2010; Federal Railroad Administration, 2015). This pattern illustrates that targeted reforms can lower regulatory costs and reduce uncertainty, but institutional and infrastructural conditions can override those effects.

FRA retained the existing safety objective throughout the Tier III rulemaking. The agency emphasized that the rule "maintains or enhances" the safety level and declined to relax crashworthiness thresholds, relying instead on modern engineering designs to achieve the objective more efficiently (FRA 2018).

c. NHTSA's Electronic Odometer Rule: The Modernization of Legacy Administrative Processes

NHTSA's odometer rule illustrates administrative regulatory lag, a form of misalignment that arises when the administrative and information-processing structures that govern compliance are built around outdated paper-based workflows and no longer match contemporary digital capacities. As states digitized their titling systems, NHTSA's paper-based disclosure requirements became increasingly misaligned with contemporary administrative practices (NHTSA 2019).

Prior to the rule, states seeking to adopt electronic disclosures had to submit individualized petitions demonstrating system security and auditability (NHTSA 2019), a process that was administratively intensive and often slow. These frictions deterred adoption, leaving most states locked into paper processes despite having digital infrastructure capable of supporting electronic workflows.

The 2019 rule reduced these frictions by eliminating individualized petitions and establishing standardized digital requirements for security, authentication, and auditability (NHTSA 2019). This shift reduced the administrative effort required for states to implement electronic systems and lowered ongoing administrative burdens. Standardized data formats and authentication requirements improved information flows and reduced manual verification.

Participation effects are emerging but uneven. Some states have adopted hybrid digital–paper workflows or partial electronic systems (AAMVA 2024), which reduce administrative burdens

even without full implementation. Motor vehicle agencies now use scanned odometer statements, electronically captured signatures on physical documents, and digital transmission of documents by dealers and third-party processors, reducing mailing delays, storage burdens, and manual verification (AAMVA 2024). Hybrid workflows are widespread, but no authoritative count exists because states adopt them incrementally rather than through discrete implementation events, and neither NHTSA nor the American Association of Motor Vehicle Administrators tracks them as a formal category. Full adoption depends on state statutory authority, vendor integration, and administrative capacity, which vary widely (AAMVA 2024). The pattern parallels the FRA case: enabling regulation can remove regulatory barriers and lower participation costs, but realized adoption depends on institutional and infrastructural conditions outside the rule itself.

The rule preserves NHTSA's fraud-prevention mandate while modernizing the mechanism through which compliance is demonstrated. NHTSA emphasized in the final rule that electronic disclosures must provide protections at least equivalent to paper systems and rejected proposals to relax authentication or security requirements on the grounds that doing so would undermine the statutory fraud-prevention objective (NHTSA 2019).

d. Cross-Case Analysis

Table 1 summarizes the form of regulatory lag, the frictions targeted, and the resulting participation effects. The cases reveal four common insights about how enabling regulation operates across distinct regulatory domains.

First, each rule responds to different forms of regulatory lag, reflecting the mix of frictions generated by misaligned regulatory structures. Part 107 addresses technological lag as its primary misalignment while also reducing administrative frictions in legacy approval pathways; Tier III addresses engineering lag while also easing technological and administrative misalignments in equipment classifications and waiver-based approvals; and the odometer rule addresses administrative lag in paper-based workflows. In each setting, the reforms replace uncertain approval pathways, outdated technical specifications, or paper-based administrative processes with standardized, risk-aligned structures that reflect contemporary technological and administrative capacities.

Second, participation effects will vary with the scale and readiness of underlying demand. Part 107 produced substantial realized activity because the rule removed frictions that directly constrained entry and because latent demand for small UAS operations was already large. Tier III and the odometer rule reduced comparable frictions, but the underlying markets were smaller or more contingent, so immediate participation effects were more limited. These differences appear in distinct patterns. Part 107 reflects an activation pattern, where removing frictions allows substantial latent demand to materialize. The odometer rule reflects a modernization pattern, where friction reduction supports incremental administrative

improvements and adoption varies across states due to differences in statutory authority, vendor integration, and administrative capacity. Tier III reflects a feasibility expansion pattern, where reduced redesign burdens broaden the set of viable options, but realized activity depends on underlying demand, institutional capacity, and the infrastructure and financing systems that shape implementation.

Third, realized participation depends on the administrative and institutional systems that support and absorb expanded activity. Part 107 scaled because FAA's certification, oversight, and waiver systems could accommodate increased participation. Tier III and the odometer rule show settings where regulatory barriers have been reduced but the administrative, infrastructural, and financing systems needed to support expanded activity are not yet in place. These institutional conditions shape whether friction reduction translates into observable activity.

Fourth, the cases suggest that the complexity of the information needed to show that existing regulatory objectives will continue to be met can shape participation patterns. In FAA's case, waivers allowed the agency to observe real-world performance under controlled conditions and supplied the operational data and safety demonstrations that formed the empirical foundation for expanded operations. This evidentiary pathway was complex and time consuming, which contributed to the delayed approval of commercial UAS operations until significant latent demand had accumulated and motivated the streamlining measures incorporated into Part 107. For FRA, harmonization with validated international crash energy management standards, supported by established modeling and test evidence, provided a ready showing that the existing crashworthiness objective would be maintained. NHTSA likewise relied on an equivalency showing, requiring that electronic disclosures provide protections at least equivalent to paper systems, a standard that could be met without generating new empirical evidence. The cases show that demonstrating that updated regulatory structures preserve the underlying objective is a key element in enabling reforms, and that the complexity of this evidentiary showing shapes both the timing of reform and the participation patterns that follow.

V. Strategic Regulatory Instruments of Enabling Regulation

The DOT cases make visible a recurring set of strategic instruments used to address the frictions created by regulatory lag. This section identifies the instruments observed and organizes them into four families: entry, classification, and compliance instruments; information and administrative infrastructure instruments; risk-responsive oversight instruments; and coordination and institutional alignment instruments. Each instrument family aligns with a specific form of regulatory lag and operates through interventions that lower the frictions that increase compliance costs, administrative burdens, uncertainty, or information asymmetries. Although analytically separable, they often operate in combination, and early participation can generate information that further reduces frictions. Together, these instrument families provide a

blueprint for managing technological change within existing regulatory structures while leaving room for tailoring to specific technological, institutional, and market conditions.

a. Entry, Classification, and Compliance Instruments

The FAA and FRA cases show how standardized entry pathways, modernized classifications, and performance aligned compliance structures reduce frictions and clarify evidentiary expectations. These instruments replace individualized approvals and outdated categories with predictable and risk-aligned pathways that lower compliance costs, reduce administrative burdens, and clarify what regulated actors must demonstrate to show that established objectives will continue to be met.

Standardized entry and certification processes provide uniform pathways that eliminate individualized demonstrations and simplify procedural steps. They reduce administrative burdens by shortening processing times and reduce uncertainty as the requirements become familiar. FAA's Part 107 replaces Section 333 exemptions with the Remote Pilot Certificate, and FRA's Tier III rule replaces individualized engineering demonstrations with a standardized approval pathway.

Updated or newly created classifications reduce misalignment between rules and technological realities. They reduce compliance costs by avoiding redesigns required by ill-fitting legacy classifications and reduce uncertainty by clarifying classification boundaries and applicable standards. FAA's creation of the small UAS category under Part 107 and FRA's establishment of the Tier III category illustrate how updated classifications reduce misalignment between rules and technologies.

Performance-aligned compliance instruments replace prescriptive requirements with assessments that identify the tests, modeling evidence, and analyses needed to demonstrate that an objective is met. They broaden the set of acceptable technological or operational approaches, reducing compliance costs when prescriptive requirements would otherwise require costly redesigns and reducing uncertainty by clarifying evidentiary standards. The complexity of these demonstrations varies across domains. FRA's performance-based crashworthiness evaluations rely on established modeling and validated international crash energy management standards, while FAA's performance-based assessments for Part 107 waiver determinations require demonstrations that proposed operations satisfy the existing safety objective. These instruments define the evidentiary pathways for demonstrating compliance.

Mapping to cost components:

- F_i: Reduced through standardized entry, modernized classifications, and flexible compliance pathways.
- A_i: Reduced through simplified procedural steps and shorter processing times.

- θ_i: Reduced as standardized pathways and performance thresholds become familiar.
- Information asymmetries: Reduced as regulators articulate expectations for new categories and compliance options.

b. Information and Administrative Infrastructure Instruments

The FAA and NHTSA cases illustrate how standardized information formats and digitized workflows reduce administrative burdens and information asymmetries. Information and administrative infrastructure instruments operate by structuring how information is generated, transmitted, and reviewed. Evidence from digital regulatory governance shows that standardized data formats, digital reporting structures, and algorithmic tools reduce administrative burdens and improve the reliability of regulatory information (Coglianese and Lehr 2017).

Standardized information formats, shared data structures, and clearer evidentiary expectations reduce information asymmetries by improving comparability and reducing the need for individualized submissions. They also reduce administrative burdens by decreasing manual verification and by clarifying what information regulators require. FAA's standardized knowledge test materials, uniform waiver templates, and shared certification data systems demonstrate how improved information structures support more predictable and efficient decision-making. NHTSA's standardized electronic odometer data fields and authentication requirements show the same logic in a different administrative context.

Digitized workflows, consolidated review processes, and the removal of obsolete procedural requirements further reduce administrative burdens by shortening processing times and eliminating outdated steps. As participation increases and regulators gain familiarity with standardized submissions, these instruments generate dynamic reductions in uncertainty. FAA's modernization of the COA process and NHTSA's removal of the petition requirement for electronic odometer disclosures each show how updated administrative workflows reduce frictions and improve information quality.

Mapping to cost components:

- A_i: Reduced through digitized workflows, standardized submissions, and the elimination of obsolete steps.
- θ_i: Reduced as improved information flows support more predictable judgments.
- Information asymmetries: Reduced through standardized reporting and shared data systems.

c. Risk-Responsive Oversight Instruments

The FRA and FAA cases show how risk-responsive oversight instruments reduce uncertainty by aligning oversight with demonstrated performance. These instruments operate after compliance has been established and use structured evidence to calibrate oversight intensity to the demonstrated risk of an activity.

FRA applies this approach in its oversight of passenger equipment. Designs supported by validated modeling and established crash energy management standards qualify for less intensive review, while novel or higher-risk configurations receive more detailed scrutiny. FAA uses a parallel structure in the operational domain. Under Part 107, operators who demonstrate that a proposed operation maintains the established level of safety may qualify for more permissive operating conditions, while operations presenting higher residual risk remain subject to stricter limitations.

Risk tiering makes oversight more predictable by clarifying the level of evidence required to qualify for more permissive conditions. FAA's risk-tiered operating restrictions under Part 107 exemplify this approach.

Mapping to cost components:

- θ_i: Reduced by clarifying evidentiary standards and aligning oversight with current technologies.
- F_i: Reduced when outdated prescriptive requirements are replaced with performance aligned evaluations.
- Information asymmetries: Reduced as risk assessment processes become more transparent.

d. Coordination and Institutional Alignment Instruments

The FAA, FRA, and NHTSA cases demonstrate that enabling regulation requires alignment with existing infrastructure, administrative systems, and institutional arrangements to support coherent integration. Coordination and institutional alignment instruments reduce uncertainty and information asymmetries by aligning regulatory requirements with complementary infrastructure, shared standards, and the institutional arrangements needed for technologies to operate within existing systems. Research on participatory and information sharing structures shows how structured review processes can reduce frictions and improve regulatory performance (Gilad 2010; Lodge and Wegrich 2015). These instruments clarify how new technologies fit within established infrastructure and improve information flows among agencies, firms, and other actors who must interact for the system to function. They reduce uncertainty by clarifying how new technologies integrate with existing systems and reduce information asymmetries through shared standards, data protocols, and coordinated institutional practices.

FRA's Tier III rule clarifies how high-speed trainsets interface with United States rail infrastructure and operating practices. FAA's integration of Part 107 with existing aviation systems provides a parallel example by creating a stable framework that later accommodated additional operational categories. NHTSA's electronic odometer rule illustrates the same logic in an administrative context, where alignment with state titling systems and existing verification practices was necessary for digital disclosures to function as intended.

Mapping to cost components:

- θ_i: Reduced by clarifying how new technologies integrate with existing systems.
- Information asymmetries: Reduced through shared standards, data protocols, and coordinated institutional practices.

e. Linking Instruments to the Economic Model

The instrument families identified in this section correspond to the mechanisms through which regulators reduce the cost components in the economic model. Each family targets the frictions generated by a particular form of regulatory lag, and their effects appear as reductions in compliance costs (F_i), administrative burdens (A_i), uncertainty (θ_i), and information asymmetries. Table 2 summarizes these relationships by linking each instrument family to the form of regulatory lag it addresses and the cost components it reduces.

VI. Implications for Regulatory Design

a. Objective Stability and Evidentiary Constraints

Enabling regulation is a strategy for governing technological change that can be applied without reopening or renegotiating the regime's substantive purpose. Its strength lies in its alignment with existing statutory and institutional frameworks, which makes it a tractable strategy when that purpose is not under reconsideration. It reduces frictions by updating misaligned elements of the regime, lowering compliance and administrative costs, reducing uncertainty about regulatory expectations, and improving information flows, thereby removing the forms of sludge that lack a legitimate justification. Although the substantive purpose may evolve as technologies and risk profiles change, reopening it introduces analytical and procedural burdens that increase the likelihood of delay. Because enabling regulation treats the regulatory objective as exogenous, it is formally a second-best strategy, yet it may be preferred in settings where revisiting the objective would introduce delay and uncertainty and where restricted participation imposes real costs during the reform process. Enabling regulation is therefore most practical when those aims are stable and the primary misalignment lies in the mechanisms through which they are implemented.

The evidentiary means for demonstrating that the objective is met are part of the existing regulatory structure, and uncertainty in these means can limit what regulators can credibly conclude. Some reforms require extensive operational data or structured demonstrations, while others can rely on established standards or straightforward equivalency. When the evidentiary burden is high, agencies may need time to generate or assemble the information required to support reform. When the evidentiary burden is low, reforms can proceed more quickly.

b. Visibility of Misaligned Structures

The viability of an enabling approach depends on the visibility of misaligned structures. Mismatches between legacy structures and current technologies must be visible to regulators, and regimes with processes for identifying frictions are more conducive to enabling approaches. Systematic ex post evaluation is one way to generate this visibility as technologies, operating contexts, and participation patterns change. DOT, for example, has established procedures for identifying frictions and creating the institutional conditions that support structural reforms within existing regulatory frameworks (U.S. Department of Transportation 2025). Visibility into misaligned structures also shapes regulators' ability to diagnose the sources of friction, because reforms can only be designed once the points of misalignment are clearly identifiable.

c. Coordinating Capacity and Structural Alignment

Coordinating capacity is central to the performance of an enabling approach. In transportation, this capacity is supplied within a mature, centralized regime, but the DOT examples show that the operative feature is the presence of coordinating functions rather than any particular institutional form. They illustrate the kinds of functions that regimes must provide: stable applicability rules, predictable compliance pathways, scalable administrative processes, and processes for updating. These functions rely on administrative and information infrastructure that supports predictable, scalable, and updatable regulatory processes. Digital reporting systems, standardized data formats, and structured evidentiary pathways reduce administrative burdens, improve information quality, and support more adaptive strategies by lowering the cost of updating requirements and integrating new information. Regulatory structures that exceed available expertise, coordination, or administrative resources generate frictions, while structures calibrated to institutional capacity reduce information asymmetries, simplify compliance, and expand participation. Designing structures that match institutional capacity is therefore essential for reducing frictions and supporting regulatory objectives.

d. Institutional Form and Coordination Mechanisms

While coordinating capacity concerns the functions a regime must provide, institutional form concerns the arrangements through which those functions are supplied. Many of these functions can be delivered through standards and shared frameworks, which create common categories, evidentiary pathways, and administrative routines that reduce uncertainty and make compliance pathways predictable across heterogeneous actors. Work on standards and collaborative

governance shows how such structures operate as coordination-enabling mechanisms that stabilize expectations and support alignment even in fragmented institutional settings (Busch 2011; Ansell and Gash 2018).

These structures also support forms of self-governance, in which coordination emerges from shared rules, common data formats, and collectively maintained evidentiary practices rather than centralized authority. Research on regulatory pluralism, meta-regulation, and experimentalist governance shows how actors can generate stable, predictable coordination through rule systems they develop and maintain themselves, even when institutional authority is distributed (Gunningham and Sinclair 1999; Gilad 2010; Sabel and Zeitlin 2012). Coordinating capacity can therefore be supplied by agencies, standards bodies, interagency processes, hybrid arrangements, or self-governing networks, and the institutional form matters less than the presence of structures that support alignment and reduce uncertainty.

e. Application to Emerging Domains

The importance of coordinating functions becomes clearer in emerging domains such as artificial intelligence, where comparable legacy frameworks are absent and fragmented institutional authority is itself a source of technological and administrative frictions. The White House's National Policy Framework for Artificial Intelligence treats many AI governance challenges as failures of outdated, inconsistent, or duplicative structures rather than gaps in substantive policy objectives (Gelbman et al. 2026). Its emphasis on safeguarding minors from AI-related risks, for example, reflects a fixed substantive purpose because that outcome is already established in federal and state child-privacy and child-protection law and in generally applicable consumer-protection statutes.

A central task in these settings is to show that new uses of technology satisfy the existing regulatory objective under contemporary conditions. The complexity of this evidentiary showing varies across applications: some uses require extensive testing, validation, or real-world performance data, while others can rely on established standards or structured equivalency. Shifting attention from debates over objectives to demonstrations of how those objectives are met clarifies the role of coordinating functions in reducing uncertainty and supporting participation. Voluntary standards such as the National Institute of Standards and Technology's AI Risk Management Framework can supply these functions by creating shared categories, evidentiary pathways, and administrative routines that reduce uncertainty and information asymmetries, thereby enabling new applications while preserving continuity in the underlying purpose (NIST 2023).

f. Synthesis

These implications clarify enabling regulation as a strategy for managing technological change by targeting the structures through which regulatory frictions accumulate. Its performance depends on a well-defined objective, visibility into misaligned structures, and institutional

capacity to supply coordinating functions such as stable categories, predictable compliance pathways, scalable administrative processes, and processes for updating. When these conditions are present, enabling regulation provides a tractable approach for realigning regulatory structures with technological and administrative conditions while preserving continuity in the underlying regime. When they are not, or when the objective itself becomes the margin of change, the advantages of the enabling approach diminish and other forms of regulatory adaptation become necessary.

VII. Conclusion

This paper has developed a conceptual and empirical account of enabling regulation as a strategy for reducing frictions, clarifying pathways, and aligning regulatory mechanisms with contemporary technological and institutional conditions. The DOT case studies show how agencies used a recurring set of instruments to modernize entry and certification pathways, update classifications, create more flexible compliance options, improve information and administrative systems, and strengthen coordination and oversight. These interventions lowered compliance and administrative costs, reduced uncertainty, and improved information flows. Across FAA's Part 107, FRA's Tier III standards, and NHTSA's electronic odometer rule, agencies identified specific forms of regulatory lag and targeted the frictions those lags created. Although the cases arise from transportation, the underlying economic dynamics are general. Legacy categories, outdated administrative processes, and information asymmetries impose costs that suppress participation in emerging technologies. These accumulated burdens function as a form of regulatory sludge, and enabling regulation offers a way to remove them while preserving continuity in the underlying purpose.

More broadly, the cases illustrate how enabling regulation operates within an existing statutory regime and its established aims. Extending this approach to emerging technologies requires first establishing a workable regime and determining the institutional arrangements capable of supplying the coordinating functions that make such a regime operable. The performance of an enabling approach depends on a well-defined objective, visibility into misaligned mechanisms, and institutional capacity to supply coordinating functions such as stable categories, predictable compliance pathways, scalable administrative processes, and routines for updating. Voluntary standards or industry-organized processes can provide the initial coordinating capacity needed to create aligned categories, compliance pathways, and administrative practices. This is consistent with the current policy environment, which anticipates a limited federal role and leaves space for nongovernmental institutions to develop frameworks that protect core regulatory objectives. Together, these insights clarify how enabling regulation can support participation and reduce frictions in domains where technological change outpaces the mechanisms through which regulatory aims are implemented.

Table 1: Cross Case Synthesis: Form of Regulatory Lag, Associated Frictions, and Participation Patterns

Case	Primary Form of Lag	Frictions	Participation Pattern
FAA Part 107	Technological	Administrative burdens in certification and waiver processes; information asymmetries; unstructured evidentiary pathways prior to Part 107	Activation: removal of binding frictions allowed substantial latent demand to materialize; rapid growth in Remote Pilot Certificates
FRA Tier III	Engineering	Redesign burdens from prescriptive crashworthiness standards; ; lack of a predictable pathway for performance-based evaluation	Feasibility expansion: expanded feasible trainset options; reduced redesign costs; improved analytical capacity, with realized activity dependent on procurement and financing cycles
NHTSA Electronic Odometer Rule	Administrative	Petition-based approval process; paper-based disclosure requirements; administrative verification burdens	Modernization: enabled digital titling modernization; reduced errors and processing time; improved fraud detection, with adoption varying across states

Table 2: Mechanisms of Enabling Regulation and Corresponding Strategic Instruments

Instrument Family	Form of Lag Addressed	Cost Components Reduced
Entry, classification, and compliance instruments	Technological	F_i, A_i, information asymmetries
Information and administrative infrastructure instruments	Administrative	A_i, θ_i, information asymmetries
Risk-responsive oversight instruments	Engineering	F_i, θ_i, information asymmetries
Coordination and institutional alignment instruments	Administrative	θ_i, information asymmetries

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Appendix A: Detailed Case Studies

A.1 FAA Part 107: Commercial UAS Operations

The Federal Aviation Administration's (FAA) Part 107 rule for small unmanned aircraft systems (UAS) provides an example of enabling regulation unlocking a latent market created by a legacy framework that had become increasingly restrictive. Prior to 2016, commercial UAS operations were governed by rules designed for crewed aviation. The default treatment of UAS as aircraft subject to traditional certification and operational prohibitions imposed substantial costs and uncertainty on prospective operators.

Legacy Constraints and Frictions

Pre–Part 107, commercial UAS operators were required to obtain case-by-case exemptions under Section 333 of the FAA Modernization and Reform Act of 2012. The exemption process was administratively intensive and timelines were unpredictable, limiting entry by many prospective operators during a period of rapidly growing. Because the legacy framework applied standards designed for crewed aviation, viable commercial UAS uses such as aerial photography, infrastructure inspection, and agricultural monitoring were suppressed by regulatory frictions rather than technological limits.[1]

Intervention and Friction Reduction

Part 107 replaced the individualized exemption process with the standardized regulatory category "small unmanned aircraft systems" and established the Remote Pilot Certificate as the primary entry requirement. The approximately $150 Remote Pilot Certificate represented a substantial decrease relative to prior requirements.[2] By removing the need for airworthiness certification, exemptions, and Certificates of Waiver or Authorization (COAs) for routine operations, the rule eliminated the individualized demonstrations that characterized the Section 333 process, replacing unpredictable approval pathways with a predictable, standardized compliance pathway.[3]

In parallel, Part 107 created a structured waiver process. Before Part 107, UAS operators seeking relief from crewed-aviation requirements had to obtain exemptions under Section 333, a process that was administratively intensive and loosely structured. Part 107 replaced that approach with a dedicated waiver mechanism tailored to small UAS operations. The rule established a uniform application format, identified the specific provisions eligible for waiver, and articulated the

[1] Operation and Certification of Small Unmanned Aircraft Systems, 81 Fed. Reg. 42064.
[2] FAA, Final Rule Regulatory Evaluation: Small Unmanned Aircraft Systems, Part 107, pp. 8–9 (June 2016) (describing the $150 Remote Pilot Certificate cost and 2elimination of the sport-pilot requirement).
[3] *Id.* at pp. 7–10 (explaining removal of airworthiness certification, exemptions, and COAs for routine operations and the shift to a standardized compliance pathway).

performance-based safety criteria applicants were required to address. FAA codified this structure in the final rule by requiring applicants to demonstrate that the proposed operation "can be safely conducted under the terms of a certificate of waiver."[4] This framework reduced uncertainty by clarifying evidentiary expectations and replaced the case-by-case judgments of the Section 333 era with a predictable, criteria-driven process.

Participation Effects and Institutional Dynamics

The regulatory analysis predicted that the changes would activate substantial latent demand and expand the set of producers for whom participation would be economically viable.[5] The realized data closely track the predictions. As shown in Table 1, more than 20,000 Remote Pilot Certificates were issued by the end of 2016, and more than 69,000 by the end of 2017. By the end of 2018, the total exceeded 106,000. Today, FAA reports nearly 428,000 certificated Remote Pilots.

Table A-1. Participation Effects Under FAA Part 107

Participation Indicator	Actual Value[1]	RIA Predicted[2]
Section 333 exemptions (pre–Part 107; as of March 16, 2016)[1]	> 4,000 exemptions	
Remote Pilot Certificates issued as 2016	20,362	
Remote Pilot Certificates issued as of 2017	69,166	47,181
Remote Pilot Certificates issued as of 2018	106,321	95,172
Remote Pilot Certificates issued as of 2019	160,302	173,684
Remote Pilot Certificates issued as of 2020	206,322	269,344
Remote Pilot Certificates issued as of 2024	427,928	

[1] https://www.faa.gov/sites/faa.gov/files/data_research/aviation/aerospace_forecasts/FY2016-36_FAA_Aerospace_Forecast.pdf; https://www.faa.gov/data_research/aviation_data_statistics/civil_airmen_statistics
[2] Part 107 RIA, Table 8, p. 56

[4] *Operation and Certification of Small Unmanned Aircraft Systems*, 81 Fed. Reg. 42064, 42106–42108 (June 28, 2016) (codifying the waiver process under 14 C.F.R. § 107.200 and specifying eligible provisions, application requirements, and safety-based evaluation criteria).
[5] FAA, Final Rule Regulatory Evaluation: Small Unmanned Aircraft Systems, Part 107, p. 56 (June 2016) (Table 8, projecting Remote Pilot participation under low- and high-case scenarios).

Waiver activity provides an additional window into participation dynamics and the information effects of standardized pathways. Early Part 107 waiver applications were often extremely brief, sometimes "two sentences or less,"[6] reflecting the information asymmetries the new framework was intended to reduce. As the system matured and operators gained a clearer understanding of expectations, the volume of waiver applications increased. Industry analyses show that in 2024 the FAA approved 809 Part 107 waivers, a 256 percent increase over the prior year, indicating both rising demand for advanced operations and growing strain on a process originally intended as a temporary bridge. [7] These trends underscore a core implication of enabling regulation: once streamlined pathways activate latent demand, administrative processes must scale in parallel or they become the next source of friction.

Part 107 did not resolve all regulatory challenges associated with integrating UAS into the National Airspace System; rather, it established the foundational architecture on which subsequent UAS rulemakings have been built. Follow-on rules include Operations Over People, [8] Remote ID, [9] and the ongoing BVLOS rulemaking.[10] These rules extend the same enabling logic by replacing individualized approvals with standardized, risk-aligned pathways that preserve the safety objective while reducing costs and uncertainty. Part 107 established a durable regulatory architecture that FAA has continued to extend through successive rulemakings.

Preserving the Safety Objective

Part 107 intentionally preserves FAA's safety objective while modernizing the mechanism through which safety is demonstrated. The rule calibrates requirements to the risk profile of small UAS operations, replacing crewed-aviation standards with proportionate operational limitations and a Remote Pilot Certificate tailored to small UAS. The waiver process extends this structure by permitting higher-risk operations when applicants demonstrate adequate mitigations, creating a predictable, risk-tiered pathway for expanded capabilities.

FAA is explicit that Part 107 maintains the existing level of safety even as it modernizes the mechanisms through which that safety is achieved. The agency declined proposals that would have lowered safety thresholds, emphasizing that operations such as flights over people, beyond

[6] Federal Aviation Administration (2022), *Waiver Trend Analysis*

[7] Robbins, M. (2025). *FAA Data Confirms What the Drone Industry Already Knows: BVLOS Rulemaking Is Urgently Needed*. Inside Unmanned Systems.

[8] *Operation of Small Unmanned Aircraft Systems Over People*, Final Rule, 86 Fed. Reg. 4314, 4316–4321 (Jan. 15, 2021) (establishing Categories 1–4, replacing waivers with standardized pathways, and integrating Remote ID as a safety-enhancing mitigation).

[9] *Remote Identification of Unmanned Aircraft*, Final Rule, 86 Fed. Reg. 4390, 4392–4394 (Jan. 15, 2021) (describing Remote ID as a digital license plate, reducing information asymmetries, and enabling advanced operations including BVLOS).

[10] FAA, *BVLOS Aviation Rulemaking Committee (ARC) Final Report* (March 2022), pp. 3–12 (recommending a risk-based, performance-oriented BVLOS framework and noting the limitations of the current waiver-based system).

visual line of sight, and night operations were excluded from the initial rule because the evidence base was not yet sufficient to support them. [11]

A.2 FRA Tier III: Passenger Rail Service

The Federal Railroad Administration's (FRA) Tier III rule for high-speed passenger rail equipment modernizes a mature engineering domain by realigning the safety requirements implemented through prescriptive standards and individualized waivers that no longer matched contemporary high-speed technologies. Prior to the rulemaking, passenger equipment standards reflected mid-twentieth-century assumptions about crashworthiness and structural integrity.

Legacy Constraints and Frictions

Before Tier III, FRA's passenger-equipment standards rested on heavy, strength-based crashworthiness assumptions. These standards were designed for conventional U.S. rail operations characterized by heavy equipment, relatively low-frequency service, and limited interoperability with freight traffic. Modern international trainsets could not be deployed in the United States without costly redesign or individualized waivers. The default reliance on static buff-strength requirements, tests of rigid carbody strength rather than modern crash-energy-management techniques, and waiver-based approvals created significant costs and uncertainty for manufacturers interested in introducing modern trainsets.[12]

Intervention and Friction Reduction

The Tier III rule replaced the waiver-driven approach with a standardized, risk-aligned framework. The rule created a new regulatory category for trainsets capable of operating at speeds up to 220 mph in dedicated corridors and up to 125 mph in shared-use environments. Rather than relying exclusively on prescriptive crashworthiness requirements, the rule incorporated performance-based crash energy management (CEM) principles and modernized safety analysis methodologies. Moreover, Tier III aligned U.S. standards with accepted international practice.[13]

The harmonization of U.S. requirements with international standards allows operators to consider modern trainsets without costly redesign and broadened the range of technologically

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[11] Operation and Certification of Small Unmanned Aircraft Systems, 81 Fed. Reg. 42064, 42070–42072 (FAA's safety-floor rationale and rejection of proposals to lower safety thresholds).

[12] *Passenger Equipment Safety Standards; Standards for Alternative Compliance and High-Speed Trainsets (Tier III)*, Final Rule, 81 Fed. Reg. 88006, 88008–88015, 88024–88028, 88035–88038 (Dec. 6, 2016) (describing legacy buff-strength and crashworthiness assumptions; incompatibility of modern international trainsets with U.S. prescriptive standards; reliance on waivers and alternative compliance; and the need to modernize standards to reflect contemporary engineering practice and global interoperability).

[13] Federal Railroad Administration, *Regulatory Impact Analysis: Passenger Equipment Safety Standards; Standards for Alternative Compliance and High-Speed Trainsets (Tier III)*, at pp. 1–3 (2018).

and administratively viable equipment options. By adopting these standards, Tier III reduced costs by eliminating the engineering modifications required under the legacy framework and reduced uncertainty by replacing case-by-case waivers with clear, rule-based approval criteria. Because Tier III specifies the conditions under which compliant equipment can operate in mixed-use corridors, the rule also lowers planning risk for operators making network-level investment decisions.[14]

Participation Effects and Institutional Dynamics

Unlike the FAA case, however, no Tier III trainsets have yet been deployed in the United States. The most advanced project, California High-Speed Rail, is now entering track construction and targeting initial service in the early 2030s but has not procured equipment.[15] This pattern reflects that near-term adoption is governed by the sequencing and financing of large-scale infrastructure rather than by equipment standards alone. The Tier III experience, and California's trajectory in particular, suggests how enabling regulation can lower regulatory costs and reduce uncertainty while adoption ultimately depends on long-horizon infrastructure and financing decisions outside the scope of the rule.

FRA's regulatory analysis reflects this structure, modeling high-speed rail development as a set of probabilistic scenarios. The rule was expected to increase the probability that a single high-speed rail corridor will be completed in the next 30 years.[16] This illustrates how enabling regulation can shift expected valuations even when actual adoption depends on infrastructure decisions beyond the rule's reach.

Preserving the Safety Objective

Tier III maintains FRA's longstanding safety objective while modernizing the mechanism used to evaluate passenger-equipment performance. Performance-based CEM criteria and interoperability requirements replace prescriptive structural mandates developed for mid-twentieth-century equipment. This shift aligns safety evaluation with the actual risks of high-speed operations and clarifies evidentiary expectations for demonstrating compliance.

FRA emphasized that the rule "maintains or enhances"[17] the existing level of safety and rejected proposals that would have relaxed safety thresholds. Modern trainsets achieve safety through advanced design, energy-management systems, and improved crash dynamics, allowing

[14] Id. at pp. 25–28 (discussion of interoperability, mixed-use operations, and evidentiary expectations).
[15] See https://railwaynews.net/california-high-speed-rail-project-san-francisco-los-angeles-hsr-network.html and https://hsr.ca.gov/2025/08/28/news-release-california-high-speed-rail-accelerates-timeline-for-2026-rail-installation/
[16] Federal Railroad Administration, *Regulatory Impact Analysis: Passenger Equipment Safety Standards; Standards for Alternative Compliance and High-Speed Trainsets (Tier III)*, at p. 34 (scenario analysis assuming a 0.10–0.25 increase in the probability that a single high-speed rail corridor is completed within 30 years).
[17] *Passenger Equipment Safety Standards; Standards for Alternative Compliance and High-Speed Trainsets (Tier III), Final Rule,* 83 Fed. Reg. 59182, 59184 (Nov. 21, 2018).

equivalent or superior safety performance at lower regulatory cost than under the legacy framework.

A.3 NHTSA Electronic Odometer Disclosures

NHTSA's rule modernizing odometer disclosure requirements reflects a case where the administrative processes for compliance themselves had become a form of regulatory lag. Under the Motor Vehicle Information and Cost Savings Act, NHTSA must ensure that odometer disclosures protect consumers from fraud. For decades, NHTSA implemented this mandate through a paper-based disclosure system requiring physical signatures and in-person transactions. NHTSA's rule modernizing odometer disclosure requirements illustrates a case where administrative processes for compliance themselves were a form of regulatory lag.[18] Under the Motor Vehicle Information and Cost Savings Act, NHTSA must ensure that odometer disclosures protect consumers from fraud.[19] For decades, NHTSA implemented this mandate through a paper-based disclosure system requiring physical signatures and in-person transactions.[20]

Legacy Constraints and Frictions

As states adopted electronic titling systems, the paper requirement imposed growing administrative burdens and uncertainty. States seeking to use electronic odometer disclosures within their digital titling systems were required to petition NHTSA for individualized approval. These petitions were administratively intensive, required detailed technical demonstrations of system security, and often took months or years to resolve. Only a small number of states pursued them, leaving most states locked into paper processes despite having digital infrastructure.[21]

Intervention and Friction Reduction

The 2019 rule replaced the petition-based structure with a standardized framework allowing states to adopt electronic odometer disclosures without individualized approval, provided their systems meet baseline security, authentication, and auditability requirements. [22]By eliminating the need for technical submissions and case-specific review, the rule reduced the upfront costs that had deterred state participation. It also lowered ongoing administrative burdens by

[18] National Highway Traffic Safety Administration (NHTSA), *Odometer Disclosure Requirements*, Final Rule, 84 Fed. Reg. 52664, 52,664 (Oct. 3, 2019) (final rule modernizing odometer disclosure requirements).
[19] Motor Vehicle Information and Cost Savings Act, 49 U.S.C. §§ 32701–32711.
[20] 49 C.F.R. pt. 580 (odometer disclosure requirements).
[21] National Highway Traffic Safety Administration (NHTSA), *Odometer Disclosure Requirements*, Final Rule, 84 Fed. Reg. 52664, 52665–66 (Oct. 3, 2019) (describing petition-based approval process for electronic disclosures and burdens of petition preparation and limited approvals).
[22] Id at pp. 52664–66 (eliminating individualized petitions and establishing baseline security, authentication, and auditability criteria for electronic disclosures).

eliminating paper processing and reduced uncertainty by establishing predictable compliance criteria.

Participation Effects and Institutional Dynamics

Electronic odometer disclosures reduce processing times, error rates, and manual verification burdens. In response to NHTSA's request for comment on electronic motor-vehicle transaction systems, industry stakeholders reported substantial cost savings from electronic odometer disclosures and related digital workflows, with estimates ranging from hundreds of millions to several billion dollars annually across vehicle sales, insurance claims, and auction transactions. NHTSA's harmonized analysis concluded that electronic transactions could save at least $457.9 million per year, with an additional $94.8 million attributable to accelerated state adoption enabled by the rule.[23]

Evidence from state implementation reflects these gains. Motor-vehicle agencies increasingly use scanned odometer statements, electronically captured signatures applied to physical documents, and hybrid workflows that blend paper and digital processes. Dealers and third-party processors routinely transmit documents electronically, reducing mailing delays, storage burdens, and manual verification requirements. These partial implementations improve data quality and reduce administrative burdens even before full electronic titling systems are in place.[24]

State adoption, however, depends on statutory authority, vendor integration, and administrative capacity. As a result, the transition to fully electronic odometer disclosures has been gradual. Beyond the original petition states, few jurisdictions have implemented end-to-end electronic systems, but many have adopted hybrid digital–paper workflows that deliver meaningful efficiency gains. The pattern parallels the FRA case: enabling regulation can remove regulatory barriers and lower participation costs, but actual adoption is shaped by broader institutional and infrastructural conditions outside the rule itself.

Preserving the Fraud-Prevention Objective

The rule preserves NHTSA's fraud-prevention mandate while modernizing the mechanism through which compliance is demonstrated. Baseline requirements for security, authentication, and auditability are calibrated to the risks of odometer tampering, replacing paper-based

[23] National Highway Traffic Safety Administration, *Electronic Motor Vehicle Transactions Systems: Summary of Public Comments*, Docket No. NHTSA-2019-0092 (Nov. 13, 2019) (reporting stakeholder cost-savings estimates and NHTSA's harmonized analysis showing $457.9 million in annual savings from electronic transactions and $94.8 million attributable to accelerated adoption under the 2019 rule).

[24] American Association of Motor Vehicle Administrators, *Guidance for the Acceptance of Signatures on Physical Odometer Disclosure Statements* (Feb. 2024)
(documenting state use of hybrid processes, electronic signature capture, scanned-document workflows, and modernization of titling systems).

processes with digital criteria that maintain the integrity of mileage information. NHTSA emphasized that electronic disclosures must provide protections "at least equivalent" to paper systems and rejected proposals to relax authentication or security requirements.[25]

[25] National Highway Traffic Safety Administration (NHTSA), *Odometer Disclosure Requirements*, Final Rule, 84 Fed. Reg. 52664, 52665 (Oct. 2, 2019) (NHTSA stating that electronic disclosures must provide protections "at least equivalent" to paper disclosures).