Data-Driven Approaches to Regulatory Compliance and Transport Licensing: Insights for a Small Public Service Vehicle (SPSV) Compliance & Licensing Analytics Dashboard

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1. Introduction

Regulation of public transport services plays a fundamental role in ensuring safety, accessibility, service quality, and consumer protection. In Ireland, the National Transport Authority (NTA), through its Transport Regulation Directorate, oversees the Small Public Service Vehicle (SPSV) sector, which includes taxis, hackneys, and limousines. This regulatory mandate involves licensing drivers and vehicles, conducting compliance and inspection activities, managing consumer complaints, and enforcing statutory requirements covering vehicle standards, driver suitability, and operational conduct (National Transport Authority, 2023).

Transport regulators internationally are experiencing rapid changes driven by digitalisation, growing public expectations, and increasingly complex mobility systems. The OECD (2021) notes that regulators can no longer rely on manual processes or reactive enforcement; instead, effective regulation now depends on the ability to collect, validate, analyse, and visualise data in real time. As mobility demand fluctuates, regulatory datasets, such as licensing records, inspection outcomes, operator behaviour, and complaint trends, have become essential for understanding the performance of the transport market and identifying where interventions are needed.

However, the existence of data does not guarantee its usefulness. Research in public-sector data management highlights ongoing challenges with data quality, fragmented records, inconsistent reporting, and limited analytics capability (European Data Portal, 2021). Without appropriate analytical tools, regulators often lack the capacity to transform raw data into actionable insights. This gap is particularly relevant for the SPSV sector, where thousands of drivers and vehicles operate across multiple regions, and where compliance issues, licence renewals, seasonal demand variations, and consumer complaint patterns can be difficult to analyse without structured decision-support systems.

This literature review examines the role of data analytics in public transport regulation, reviews international research on licensing systems, discusses best practices in compliance monitoring and risk-based enforcement, and highlights the importance of dashboards as regulatory decision-support tools. The review concludes with a clear problem statement that guides the development of a proposed SPSV Compliance & Licensing Analytics Dashboard.

2. Regulatory Data and Digital Transformation in Transport

2.1 Importance of Data in Transport Regulation

Modern transport regulation increasingly relies on the ability to collect, validate, analyse, and interpret large volumes of operational and compliance data. According to the International Transport Forum (ITF, 2021), data-driven governance is fundamental to modernising oversight and improving regulatory efficiency. The ITF encourages regulators to transition from reactive enforcement to proactive, intelligence-led approaches supported by real-time analysis and risk-based prioritisation.

The European Commission (2023) identifies transport digitalisation as a strategic objective for EU member states, emphasising integrated digital systems for licensing, enforcement, and fleet monitoring.

These systems are intended to support:

- Real-time data capture
- Automated compliance reporting
- Enhanced visibility of operator behaviour
- Efficient resource deployment
- Improved policymaking

Research indicates that data-driven regulation leads to measurable improvements in the detection of non-compliance, optimised allocation of enforcement resources (OECD, 2021), increased transparency (World Bank, 2022), and improved forecasting accuracy regarding transport demand and operator availability (Fayyaz et al., 2020).

For the SPSV sector, these insights translate into potential improvements in monitoring driver licensing patterns, vehicle renewals, regional supply distribution, accessibility compliance, inspector performance, and passenger complaint trends.

2.2 Data Quality and Governance Challenges

Although data availability is expanding, challenges persist. Studies on public-sector digitalisation highlight issues such as incomplete records, variations in data quality, poor integration between legacy systems, and heavy reliance on manual reporting processes (European Data Portal, 2021). These challenges make it difficult to conduct trend analysis, identify anomalies, or generate consistent reporting.

UNECE (2022) similarly notes that many regulatory organisations struggle with fragmented datasets, which limits their ability to conduct cross-dataset analysis, forecast service needs, or evaluate operator behaviour. For transport regulation, these issues may affect:

- The accuracy of licensing statistics

- Detection of inspection patterns
- Understanding of complaint trends
- The ability to plan risk-based enforcement

Effective dashboards help address these challenges by applying standardised data cleaning, automated validation, and consistent KPI structures, providing regulators with an accessible view of system performance.

3. Transport Licensing Systems and Global Insights

3.1 Characteristics of Licensing Systems

Transport licensing systems are responsible for ensuring that drivers and vehicles meet specific criteria relating to safety, accessibility, qualifications, and consumer protection. Comparative studies of taxi, ride sourcing, and private-hire regulation (Rogers et al., 2021; ITF, 2019) highlight several core regulatory objectives:

- Ensuring a safe and well-maintained fleet
- Preventing illegal or unlicensed operation
- Maintaining geographic service coverage, especially in rural areas
- Protecting passengers from misconduct or overcharging
- Upholding accessibility obligations for persons with disabilities

Research identifies several key indicators that stakeholders examine within licensing datasets:

- Licence renewal rates
- Licence attrition and lapse trends
- Regional distribution of active operators
- Operator compliance history
- Complaint frequencies and categories
- Demographic changes among licensees

Dashboards that consolidate these indicators are shown to improve regulatory planning, operator oversight, and strategic decision-making (Morelli et al., 2020).

3.2 Digital Licensing and Public-Sector Modernisation

Digitalisation has transformed licensing processes globally. Online systems now automate applications, renewals, document checks, and payments. According to the OECD (2020), these digital systems not only reduce administrative burden but also improve transparency, auditability, and data quality.

However, digital licensing alone does not deliver full regulatory value. The European Commission (2023) stresses that digital systems must be paired with visual analytical

tools so regulators can identify trends, anomalies, and risks. Dashboards, when used correctly, convert static licensing data into dynamic, interpretable insights that support decision-making.

4. Compliance Monitoring and Intelligence-led Enforcement

4.1 The Shift from Reactive to Intelligence-led Regulation

Traditional transport enforcement relies on routine inspections and reactive responses to complaints or incidents. While necessary, this approach can be inefficient when inspector resources are limited. The OECD (2021) advocates shifting toward intelligence-led enforcement, where inspection activity is planned based on risk, historical compliance levels, and operator behaviour.

- Risk-based regulation supports:
- Prioritising high-risk operators
- More efficient use of inspection resources
- Improved fairness and transparency
- Better compliance outcomes

For example, operators with consistent compliance may require fewer interventions, while those with repeated complaints or vehicle failures may require targeted enforcement.

4.2 Predictive Analytics and Machine Learning in Compliance

Predictive modelling is increasingly used to support regulatory decision-making. Studies in transport analytics demonstrate the potential of:

- Clustering algorithms to group operator behaviour
- Time-series forecasting to anticipate demand or renewal cycles
- Anomaly detection to flag unusual activity in complaints or inspection patterns
- Regression models to identify factors associated with non-compliance

Fayyaz et al. (2020) show that even simple predictive models can significantly improve the ability of transport authorities to anticipate service shortages or identify underperforming routes. Applied to the SPSV sector, similar models could forecast:

- Expected licence renewal spikes
- High-risk operators requiring inspection
- Emerging geographic gaps in SPSV availability

4.3 Complaints and Consumer Protection

Complaint data is a critical regulatory resource. According to the World Bank (2022), structured complaint analysis helps regulators identify systemic service issues, track response times, and assess the reliability of operators. Complaint patterns can also function as early indicators of poor quality service or operator misconduct.

Heatmaps, complaint category classification, and trend analysis are widely used in regulatory dashboards across other sectors. These models could provide significant value if applied to SPSV complaints data.

5. Dashboards and Visual Decision-Support Systems

5.1 Value of Dashboards in Public-Sector Regulation

Dashboards have become central to modern public-sector management. The European Data Portal (2021) notes that dashboards help streamline reporting, improve public transparency, and enable regulators to understand trends at a glance. They also allow real-time monitoring of key indicators, reducing reliance on static reports.

For transport regulators, dashboards offer benefits such as:

- Visual oversight of licensing metrics
- Monitoring compliance inspection activity
- Tracking complaint volumes and types
- Identifying regional differences in service availability
- Enabling cross-team collaboration

Such tools allow executives, inspectors, analysts, and policymakers to work from a shared understanding of regulatory data.

5.2 Best Practices in Dashboard Design

Scholars such as Few (2017) and Munzner (2014) provide widely-adopted principles for dashboard design, emphasising:

- Simplicity and clarity
- Use of appropriate chart types
- Minimisation of cognitive load
- Consistent formatting and colour usage
- Interactivity and drill-down capability
- Automated data refresh
- Strong data quality foundations

For SPSV regulation, dashboards should incorporate KPIs relating to:

- Active licences
- Renewal patterns
- Failed inspections
- Complaint categories
- Geographic availability
- Monthly compliance trends
- Enforcement activity

6. Gaps in Current Research and Practice

Despite strong international advances in regulatory analytics, several gaps remain relevant to SPSV oversight:

1. **Limited published research on SPSV-style regulatory environments.**
   Most academic work focuses on large ride-hailing markets rather than smaller, regulated taxi systems.
2. **Fragmented regulatory datasets.**
   Research suggests that many transport authorities still manage data in siloed systems, limiting the ability to build integrated dashboards (European Data Portal, 2021).
3. **Underuse of predictive analytics.**
   Although predictive modelling is common in transport operations (e.g., forecasting ridership), it is seldom applied to compliance or licensing.
4. **Lack of unified decision-support tools.**
   There is a shortage of dashboards designed specifically for combining licensing, enforcement, and complaint data.

These gaps highlight the need for a tool tailored to Ireland's SPSV sector, combining licensing data, complaint analysis, compliance trends, and predictive indicators.

7. Problem Statement

While data-driven regulation is widely recognised as essential for modern transport oversight, there is no unified analytical tool for the SPSV sector that integrates licensing, compliance, complaint, and operator-level data into a single decision-support platform.

The SPSV sector currently faces challenges, including:

- Fragmented data sources
- Inconsistent reporting structures
- Limited proactive risk identification
- Reliance on manual interpretation of datasets
- Lack of predictive tools for compliance or licensing trends

Therefore, this project proposes the development of an SPSV Compliance & Licensing Analytics Dashboard incorporating:

- Data preprocessing and validation
- Visualisation of licensing, complaint, and compliance trends
- Risk-focused indicators
- Predictive analytics for forecasting operator behaviour and renewal patterns

Such a dashboard would enhance evidence-based regulation, support inspectors and policymakers, and strengthen public confidence in the SPSV system.

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