

Oksana Boikiv*Vasyl Stefanyk Precarpathian National University, Ivano-Frankivsk, Ukraine**E-mail: oksanaboikiv@yahoo.com**ORCID: <https://orcid.org/0009-0008-1401-2340>*

An Information Model for Accounting-Regulatory-Operational Data Convergence in Us Small-Carrier Trucking

Abstract

This study *aims* to conceptualize the distinctive accounting-information environment of American small-carrier trucking, where a single owner-operator or a management team of one or two persons typically manages freight movement, financial recording, tax compliance, and equipment tracking as an integrated activity. The study addresses a gap between accounting-information-system research, which generally treats operational technology and financial recording as separate but periodically integrated layers, and trucking operations research, which typically considers accounting an administrative function following dispatch and fuel-card processes. *Methodology.* The study applies a conceptual and systems-based approach to the analysis of operational and accounting information flows in US small-carrier trucking. Particular attention is given to data generated by electronic logging devices, telematics systems, and fuel cards and to their simultaneous use as accounting inputs, regulatory tax-base information under the International Fuel Tax Agreement (IFTA), and managerial performance indicators. Industry cost data are used to contextualize the operating environment: the American Transportation Research Institute reports an industry-average operating cost of \$2.260 per mile in 2024, with non-fuel operating costs reaching a record \$1.779 per mile. *Results.* The study produces three principal artifacts. First, it formalizes the data-identity property specific to US small-carrier trucking, whereby the same operational data simultaneously perform accounting, regulatory, and managerial functions. Second, it proposes the Small-Carrier Accounting Information Model (SCAIM), a four-node data-flow architecture comprising operational, financial-ledger, regulatory-filing, and managerial-dashboard components. Third, it develops an Integration Quality Score structured across three information flows and two dimensions as a diagnostic instrument for evaluating the information setup of an individual carrier. IFTA quarterly reporting illustrates how a single operational data stream can support four simultaneous outputs. *Practical implications.* The proposed framework provides small carriers and owner-operators with a structured approach to integrating operational, accounting, regulatory, and managerial information. SCAIM and the Integration Quality Score can be used to identify weaknesses in information flows, reduce duplication in data processing, improve regulatory reporting, and strengthen the use of operational data for financial and managerial decision-making.

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small-carrier trucking
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1 Introduction

US trucking moved 11.27 billion tons of freight in 2024 and generated \$906 billion in gross freight revenues, per the American Trucking Associations (2025). Approximately 580,000 active motor carriers registered with the Federal Motor Carrier Safety Administration (FMCSA) (2025) own or lease at least one tractor as of mid-2025. Trucks carry 67 percent of the value of surface trade between the United States and Canada (American Trucking Associations (ATA), 2025).

Structural composition of the industry concentrates at the small end. FMCSA Motor Carrier Management Information System registration data as of December

2023 show that 91.5 percent of active US motor carriers operate ten or fewer trucks, and 99.3 percent operate fewer than 100. Among for-hire carriers specifically, roughly 70 percent hold only one power unit, and 97 percent hold ten or fewer (Federal Motor Carrier Safety Administration (FMCSA), 2025). Concentration at this scale means that a majority of US freight capacity operates from firms without a chief financial officer, without a controllership function, and often without a dedicated bookkeeper working full time.

Cost pressure has intensified since 2020. According to the American Transportation Research Institute (ATRI), which has published its Analysis of the Operational Costs of Trucking annually since 2008, the industry-average operating cost reached

\$2.270 per mile in 2023 and \$2.260 per mile in 2024 (American Transportation Research Institute (ATRI), 2024; American Transportation Research Institute (ATRI), 2025). Non-fuel operating costs rose to \$1.779 per mile in 2024, the highest figure ATRI has recorded (American Transportation Research Institute (ATRI), 2025). Applied to 2024 marginal costs, driver compensation (wages plus benefits) accounts for approximately 44 percent of cost per mile, fuel for approximately 21 percent, equipment payments for 17 percent, repair-and-maintenance for 9 percent, and insurance-permits-tires-tolls-licensing for the residual 9 percent (American Transportation Research Institute (ATRI), 2025). Average operating margins for truckload carriers fell below six percent across all fleet sizes outside the less-than-truckload segment in 2023, and downward pressure continued in 2024 (American Transportation Research Institute (ATRI), 2024).

Economic conditions of that magnitude place stress on small-carrier accounting practice. A property of that segment distinguishes it from other small-business accounting contexts and is not addressed in existing literature. Operational technology at a small carrier generates three continuous data categories: hours-of-service records from electronic logging devices (ELDs), mileage and route data from telematics, and per-transaction fuel purchases from fuel cards. Each of these data types serves multiple purposes on the same timescale. Mileage recorded by telematics forms the billing basis for shipper invoicing, the payroll basis for driver settlement under paid-mile compensation structures, the regulatory tax base for quarterly IFTA fuel-tax allocation across states, and the managerial metric for per-lane profitability analysis. Fuel-card transactions form the cost-of-service ledger entry, the IFTA fuel-purchase-by-state credit calculation, and the managerial fuel-efficiency metric. ELD hours become the payroll basis under hourly and salary compensation and the source of record for FMCSA hours-of-service audit response. Raw data carries three or more simultaneous semantic roles from the moment of capture.

Two bodies of research address the accounting side and the operational side of small-carrier trucking, respectively, but do not intersect on the data-identity question. Foundational accounting-information-system (AIS) contributions established the shared-data-environment framing of accounting through the REA (resources, events, agents) framework of McCarthy (1982), which departs from journal-entry-centric models. Continuous auditing research extends this framing to real-time assurance methodology (Vasarhelyi, Alles & Kogan, 2004; Chan & Vasarhelyi, 2011). Big-data research examines implications for managerial and financial accounting practice (Warren, Moffitt & Byrnes, 2015). AIS methodological direction is discussed by Sutton (2005), and journal-entry data-mining applications by Debreceeny and Gray (2010). AIS literature works at the level of generic firm and

does not distinguish contexts in which operational data is coextensive with accounting data from contexts in which operational data feeds accounting through subsequent transformation.

Trucking operational research addresses ELDs, telematics, and safety technology from a compliance-and-safety perspective. Empirical studies on ELD adoption examine the December 2017 mandate implementation phases and downstream effects on driver hours, crash rates, and small-carrier compliance behavior (Miller, et al., 2017; Cantor, et al., 2016; Hickman, et al., 2017). Belzer's work on trucking industry economics documents how deregulation-era price competition shapes the small-carrier segment's thin-margin structure (Belzer, 2000). Operational research literature does not address the accounting-function implications of the data these technologies generate, treating accounting as an administrative activity that follows operations.

The aim of the article is to formalize the data-identity property specific to US small-carrier trucking accounting and to construct an architectural response that bridges the accounting-information-system and trucking-operations research streams. The Small-Carrier Accounting Information Model (SCAIM) constitutes that response. Four connected objectives structure the article. First, the article documents the data-identity property with reference to ELD, telematics, and fuel-card data streams and their multi-purpose semantic roles under US federal and state regulatory regimes. Second, the article constructs SCAIM as a four-node data-flow architecture (operational data source, financial ledger, regulatory filing surface, managerial dashboard) connected by three flows, with each flow's data granularity and transformation logic specified. Third, the article develops an Integration Quality Score across three flows and two dimensions (data freshness and transformation transparency). External accountants can apply the instrument during engagement onboarding or after material information-system changes at the client firm. Fourth, the article illustrates SCAIM through one continuous use case: IFTA quarterly reporting. This case draws on a single operational data stream (telematics mileage combined with fuel-card transactions) for four simultaneous outputs (shipper invoicing, driver settlement, IFTA state-by-state fuel tax allocation, per-lane profitability analysis).

Section 2 reviews the accounting-information-system and trucking-operations literatures and locates the data-identity gap. Section 3 describes materials and methods. Section 4 presents SCAIM as an artifact, together with US small-carrier trucking descriptive statistics, the Integration Quality Score instrument, and the IFTA use case. Section 5 discusses why data-identity is trucking-specific, implications for AIS design, practical positioning of SCAIM for external accountants, and limitations. Section 6 concludes and identifies research directions.

2 Literature Review

2.1 Accounting-information-system foundations

Modern AIS research begins with the conceptual reformulation by McCarthy (1982). Before REA, accounting systems were designed around chart-of-accounts organization: transactions were coded to accounts, aggregated to journals, and posted to ledgers. Non-accounting users of the underlying business events (production planners, tax authorities, managers) received filtered outputs that had lost the original event structure. McCarthy proposed a semantic model organized around three primitives: resources (what was exchanged), events (when and how), and agents (who participated). Under this formulation, one economic event is stored once at full granularity, and each subsequent view (financial-statement, management-report, tax-return) becomes a projection of that stored event. McCarthy's 1982 publication received the first "Seminal Contribution to the AIS Literature Award" from the American Accounting Association in 1996 and remains the theoretical anchor for AIS design that treats accounting as a shared data environment.

Continuous auditing research extends REA-adjacent thinking into assurance. Vasarhelyi, Alles, and Kogan (2004) specify the demand-side, supply-side, and technology-side conditions under which continuous assurance becomes feasible: transactional data available in machine-readable form, analytic monitoring rules encoded as logical statements, and exception-based reporting instead of periodic full-sample review. Their principle of analytic monitoring assumes that the audit reviews the same transactional stream that the accounting system uses for financial reporting, and both proceed from a shared underlying data record. Chan and Vasarhelyi (2011) survey the practical implementation of continuous auditing at large firms after two decades of research and identify persistent gaps in real-world deployment beyond pilot studies. Their observations concern enterprise-scale deployments and do not address small firms.

Big-data research on accounting emphasizes new data types. Warren, Moffitt, and Byrnes (2015) argue that video, audio, textual, and sensor data will change managerial accounting through improved measurement of activities that historically lacked quantification, and financial accounting through richer disclosure supported by non-transactional evidence. Alles and Gray (2016) examine adoption barriers to big-data audit techniques and inventory inhibitors: skill gaps, tool cost, sample-versus-population methodological disagreement, and audit-standard compatibility. Debreceeny and Gray (2010) apply data-mining techniques to journal-entry populations for fraud detection, and in a subsequent research agenda (Debreceeny & Gray, 2011) extend the approach to unstructured text data from electronic communications. Common to these studies is

treatment of data as a large accumulated volume for periodic analysis, and not as a continuous flow that carries simultaneous accounting, regulatory, and managerial roles at the moment of capture.

Sutton's editorial commentary (Sutton, 2005) situates AIS research in a discipline that has struggled to attract PhD students and to publish in top-tier accounting journals despite forty years of scholarship. His observation is relevant to the present article's positioning: AIS work that studies small-firm data environments falls between the accounting mainstream (which favors public-company samples) and the information-systems mainstream (which favors technology-adoption case studies). Trucking-specific AIS work must locate itself in this thin overlap.

AIS foundations from McCarthy (1982) through recent big-data extensions treat data-source characteristics as generic. Whether the underlying data originates in a manufacturing process, a retail point-of-sale system, or a fleet telematics device does not alter the framework's application. Specificity of trucking operational data, including its regulatory encoding under IFTA and FMCSA rules, its per-transaction financial materiality, and its role as simultaneous input to at least three functional views, remains outside the frame.

2.2 Trucking-Operations Research

Trucking industry economics form a distinct research tradition. Belzer (2000) documents the post-1980 deregulation transformation of US trucking into a segment characterized by thin margins, high driver turnover, and structural downward pressure on labor compensation. Real driver earnings declined approximately 30 percent between 1977 and 1995 despite employment growth of nearly four percent annually. Belzer's argument connects wage compression to operational safety through driver fatigue and workload pressure. Belzer's framework does not extend to accounting-function design; accounting appears as background overhead in his cost analyses.

Cantor, Corsi, Grimm, and Singh (2016) examine the relationship between technology adoption, firm size, and safety outcomes in US motor carriers using FMCSA safety measurement data. Their finding that safety-technology adoption correlates with firm size and typically precedes safety improvement establishes a template for how researchers approach trucking-technology questions: technology-in as independent variable, safety-out as dependent variable. Accounting-function characteristics do not enter as either predictor or outcome.

Empirical study of the December 2017 ELD mandate follows the same template. Miller and colleagues (2017) examine ELD compliance among small and medium carriers in the four months preceding the mandate deadline. Their finding that fewer than 15 percent of

smaller carriers had begun ELD adoption three months before the deadline documents the compliance-lag pattern typical of regulatory transitions in this segment. Hickman and colleagues (2017) use carrier-collected data to estimate post-mandate safety effects and find an 11.7 percent reduction in total crash rates for ELD-equipped trucks, together with reductions in preventable crashes and hours-of-service violations. Both studies treat ELD as a safety technology with regulatory backing; neither examines the parallel role of ELD-generated data as accounting input, payroll basis, or IFTA reporting substrate.

Two industry-research sources provide the empirical benchmark for trucking-cost analysis. ATRI publishes the Analysis of the Operational Costs of Trucking annually with granular per-mile cost breakdowns (ATRI, 2024; ATRI, 2025). In the 2024 edition, ATRI reports 2023 industry-average cost of \$2.270 per mile with driver wages at \$0.779 and fuel at \$0.553; the 2025 edition reports 2024 industry-average cost of \$2.260 per mile with driver wages at \$0.798 and fuel at \$0.481. ATRI reports are practitioner-oriented benchmarking studies, not academic contributions in the AIS or accounting-theory sense, and their framing treats accounting as one line item alongside fuel and equipment. ATA's Economics and Industry Data (2025) provides the aggregate market-size context (revenue, tonnage, carrier counts) that supports macroeconomic positioning of trucking within the US economy.

2.3 Regulatory Documentation as Primary Source

Two regulatory documents anchor the illustrative case at the center of the article. FMCSA published the ELD final rule in the Federal Register on 16 December 2015 (FMCSA, 2015), with compliance mandated by 18 December 2017 for carriers previously using paper logs and by 16 December 2019 for carriers using older automatic on-board recording devices. Rule content codified at 49 CFR Part 395 Subpart B specifies device certification standards, data transfer protocols, and record retention requirements. IFTA's Articles of Agreement (International Fuel Tax Association, Inc. (IFTA) establish the multi-jurisdiction fuel-tax reporting framework that governs how mileage and fuel data from operational systems translate into state-by-state tax allocation. IFTA covers 48 US contiguous states and 10 Canadian provinces, uses quarterly reporting deadlines on April 30, July 31, October 31, and January 31, and imposes a standard penalty of \$50 or 10 percent of net tax owed for late filings.

Regulatory sources supply the institutional framework within which small-carrier accounting operates, but they are not analyzed as accounting-design inputs in either the AIS or the trucking-operations literature. FMCSA documents specify what data must be captured for safety enforcement; IFTA

documents specify what data must be reported for tax reconciliation. Whether the same data records serve simultaneous accounting purposes is left to individual carriers to determine, without theoretical guidance.

2.4 Government Data Sources for Population Statistics

Aggregate small-carrier population statistics come from FMCSA's Motor Carrier Management Information System (2025) through the Analysis and Information portal and from Bureau of Transportation Statistics compilations (2025). Both sources support cross-sectional profiling: carrier size distribution, geographic concentration, entity-type classification (for-hire versus private, hazardous-materials versus general freight). They are not intended as accounting-research inputs and do not link carrier characteristics to accounting practice.

2.5 What Has Not Been Examined

Three specific gaps emerge from the reviewed literature.

AIS scholarship has not examined trucking accounting as a domain where operational-data streams and accounting entries are the same records under different names. McCarthy's REA framework (1982) provides the theoretical vocabulary (events, resources, agents) needed for such analysis, and continuous auditing (Vasarhelyi, Alles & Kogan, 2004; Chan & Vasarhelyi, 2011) provides the assurance framework for real-time data flows, but neither has been applied to the trucking accounting context. Domain-specific integration of ELD hours, telematics mileage, and fuel-card transactions into an REA-style event model is absent from published AIS research.

Trucking-operations scholarship has not examined the accounting-function implications of operational technology adoption. Miller (2017), Hickman (2017), and Cantor (2016) establish that ELD, telematics, and safety technology affect driver behavior and safety outcomes. None examine whether these technologies also reshape the accounting function through the data they generate. Existing literature treats operational technology and accounting as separate concerns of the firm.

Regulatory analysis at the intersection of IFTA quarterly reporting and general-ledger accounting has not been undertaken in academic literature. IFTA documentation describes reporting mechanics; trucking-industry practitioner literature describes how carriers should organize their fuel receipts and mileage records; AIS literature describes how accounting systems should handle regulatory reporting in general. IFTA specifically, where the source data for quarterly returns is the same data that flows into shipper billing,

driver settlement, and per-lane profitability analysis, has no dedicated academic treatment.

Three identified gaps combine into the missing artifact that the article constructs in Sections 3–5.

3 Materials and Methods

SCAIM development follows a conceptual-analytical design with three components: narrative review of two research literatures, structured examination of primary regulatory documents and industry data, and construction of a data-flow architecture through domain-specific instantiation of an established modeling primitive. Validation proceeds through logical coherence with the underlying modeling primitive, correspondence with independently documented regulatory requirements, and internal consistency between architectural components.

3.1 Source Material

Four categories of source material inform the article.

Peer-reviewed academic literature was identified through targeted search on named authors and research streams pre-identified as relevant to the article's argument. Ferrari (2015) provides methodological baseline for narrative-review construction; formal systematic-review procedures were not applied, and citation-count thresholds were not used as inclusion criteria. Two research streams were covered: AIS foundations and extensions (McCarthy REA, 1982); continuous auditing (Vasarhelyi, Alles & Kogan, 2004); big-data in accounting (Debreceeny & Gray, 2011; Alles & Gray, 2016); methodological direction and US trucking operations and economics (post-deregulation industry economics (Belzer, 2000); technology-firm-size analyses (Cantor, et al., 2016); ELD-adoption compliance and safety effects (Miller, et al., 2017). Selection prioritized studies that reported design, sample size, and empirical setting.

Trucking-industry benchmarking data come from ATRI's Analysis of the Operational Costs of Trucking annual publications, drawing on the 2024 edition (based on 2023 data from 178,091 combination truck-tractors) and the 2025 edition (based on 2024 data from 178,091 combination truck-tractors covering 14.08 billion miles). ATA's Economics and Industry Data portal supplies aggregate market statistics including 2024 gross freight revenue and total tonnage moved (ATA, 2025). Cost-per-mile line items, driver-compensation subtotals, and equipment-payment trends were extracted from ATRI press releases and accompanying industry-media coverage of the 2024 and 2025 editions; primary ATRI reports were not accessed directly.

Government administrative data come from FMCSA's Motor Carrier Management Information System (MCMIS) through the Analysis and Information portal (2025), accessed for carrier-size distribution and active-carrier counts as of the December 2023 and mid-2025 snapshots. Bureau of Transportation Statistics (2025) compilations were consulted for historical carrier-population trends and cross-mode freight statistics.

Primary regulatory documentation was retrieved from the Federal Register and from IFTA International's official site. FMCSA's Electronic Logging Devices and Hours of Service Supporting Documents Final Rule (80 FR 78385) was accessed through federalregister.gov for the December 2015 rule text, its December 2017 compliance phase, and its December 2019 full-implementation deadline. IFTA Articles of Agreement were retrieved from iftach.org for the quarterly-reporting framework, member-jurisdiction list, and penalty schedule. Each source is publicly available at no cost and was used without modification.

3.2 Framework Construction Procedure

SCAIM construction followed a four-stage procedure.

Stage one articulated the data-identity property through domain-knowledge synthesis on three trucking-operational data types (ELD hours-of-service records, telematics mileage and fuel consumption, and fuel-card transactions), each of which serves accounting, regulatory, and managerial functions on the same timescale. Selection of these three data types over others (paper driver logs, dispatch software output, shipper-invoice records, or bookkeeping-software input forms) reflected two criteria: continuous machine-generated capture (excluding paper logs and manual invoice entry), and federal or interstate regulatory encoding (excluding dispatch-only and internal-management-only data). Documentation of structural characteristics preceded framework construction.

Stage two selected a modeling primitive from AIS theory adequate to represent the data-identity property. McCarthy's REA framework (1982) was chosen because chart-of-accounts-centered frameworks assume accounting entries as the primary record, whereas REA's event-centric organization stores each economic event once at full granularity and generates each functional view as a projection of the stored event.

Stage three specified the four nodes and three flows of the SCAIM architecture. Nodes correspond to functional views of stored events: operational data source (Node A), financial ledger (Node B), regulatory filing surface (Node C), and managerial dashboard (Node D). Flows correspond to the transformation

paths through which Node A data reaches Nodes B, C, and D: operational-to-financial ingestion (Flow 1: A→B), operational-to-regulatory direct (Flow 2: A→C), and dual-source managerial feed (Flow 3: A + B → D). Flow 2 bypasses the ledger and shows that regulatory reporting derives from operational data without ledger intermediation, which is the architectural signature of the data-identity property.

Stage four developed the Integration Quality Score instrument on three flows across two dimensions. Freshness dimension measures elapsed time between operational-data capture and functional-view availability, on a three-level scale (same-day within business day of capture; weekly 1–7 days lag; monthly-or-longer beyond 7 days lag). Transformation-transparency dimension measures documentation quality of the mapping between source data and functional view, on a three-level scale (documented with reproducible rules; partially documented; undocumented). Criteria were selected on the basis that each must be verifiable through documentation available to an external accountant during an initial engagement.

Acronym conflict-checking on SCAIM was conducted through Google Scholar and general web search on the exact string in quotes combined with domain terms ("SCAIM accounting", "SCAIM information model"). No conflicting active use was returned in accounting, trucking, or information-systems literatures.

3.3 Choice of a Four-Node Three-Flow Structure

Four nodes and three flows depart from the three-tier hierarchies common in generic AIS architecture. Two considerations motivate the choice.

First, three flows (not four) capture that Node A is the shared source and Nodes B, C, D are its projections. A four-flow structure with B→C, B→D, and C→D reciprocal paths would misrepresent the data-identity property by implying that ledger entries drive regulatory filings, when in the trucking case the reverse holds: operational records supply both ledger entries and regulatory filings from a common source. Absence of B→C and B→D as primary flows is architecturally informative.

Second, Node C exists as an independent node and not as an output of Node B because trucking regulatory reporting is not derivative of accounting reports. IFTA quarterly returns are not extracted from the general ledger; they are calculated directly from telematics mileage and fuel-card transactions. FMCSA hours-of-service audit response draws directly on ELD records, not on payroll journal entries. Node C's independence from Node B is the specific architectural claim distinguishing trucking from other SME contexts where regulatory reporting can be viewed as a ledger-derived output.

3.4 Visualization and Analytical Tools

Descriptive statistics on US small-carrier trucking (Figure 1 panels a and b, Table 1) were computed in Python 3.11 with pandas 2.x and matplotlib 3.x, using the Agg non-interactive backend for reproducible PNG output. Cost-per-mile data were extracted from ATRI press releases and industry-media coverage of the 2024 and 2025 editions (ATRI, 2024; ATRI, 2024); carrier-size distribution data were extracted from FMCSA MCMIS snapshots as reported through the A&I portal (FMCSA, 2025). Extraction dates for each series are recorded in the caption of the figure or table in which the data appear.

Figure 2 (SCAIM node-and-flow diagram) was constructed in matplotlib as a directed-graph visualization, with node positions arranged to make Flow 2 (A→C) visually distinct from Flow 1 (A→B) and Flow 3 (A + B → D). Palette choice used a neutral warm gray-brown range for coherence with the article's own visual identity.

Table 2 (Integration Quality Score matrix) was constructed as a three-flow by two-dimension grid, with each cell containing a three-level rubric (same-day / weekly / monthly-or-longer for freshness; documented / partial / undocumented for transformation transparency). Table 3 (IFTA illustrative case) was constructed by tracing a single operational data stream (telematics mileage combined with fuel-card transactions) through its four simultaneous outputs, with discrepancy sources documented for each mapping.

3.5 Types of Claim Supported and Not Supported

Framework construction method supports three types of claim and does not support two.

Supported claims: logical coherence of the SCAIM architecture with the REA modeling primitive (McCarthy, 1982); correspondence of Flow 2 (A→C direct) with independently documented FMCSA and IFTA reporting requirements (FMCSA, 2015; IFTA); diagnostic utility of the Integration Quality Score as an instrument for flow-level self-assessment across three flows and two dimensions, applied by external accountants engaging with small-carrier clients.

Not supported claims: predictive validity of SCAIM at the level of carrier-outcome prediction (survival, revenue, safety, or margin improvement); causal claims that carriers adopting SCAIM-informed information architecture will outperform carriers that do not. Both claim types require longitudinal panel data at the small-carrier level with observable information-architecture variation across firms, and are identified in Section 6 as research directions.

4 Results

4.1 US small-carrier trucking context

Descriptive statistics on US small-carrier trucking establish the empirical setting in which SCAIM operates. Table 1 aggregates market-scale and structural indicators.

Figure 1 presents carrier-size distribution alongside cost-composition data from ATRI benchmarking research.

Cost composition in Panel (b) documents that driver compensation (wages plus benefits) forms 44 percent of per-mile cost, fuel forms 21 percent, equipment payments and maintenance combined form 26 percent, and insurance and other line items form the residual 9 percent.

4.2 SCAIM architecture

Figure 2 presents the SCAIM artifact.

Node A captures three operational data categories at full granularity: ELD hours-of-service records at the driver-shift level, telematics mileage and fuel consumption at the trip-segment level, and fuel-card transactions at the per-purchase level. Each record retains standard operational metadata (timestamp, geographic coordinates, driver and tractor identifiers), with fuel-card records adding fueling-station identifier and product code.

Node B ingests Node A data through Flow 1 to produce financial-ledger entries. ELD hours become the payroll basis for hourly and salaried drivers; telematics mileage becomes the payroll basis for paid-mile drivers and the revenue-recognition basis for shipper invoicing

TABLE 1 US trucking industry structural indicators, 2023–2024

Indicator	Value	Source
Gross freight revenue (primary shipments)	\$906 billion in 2024	ATA (2025)
Domestic truck tonnage moved	11.27 billion tons in 2024	ATA (2025)
Active FMCSA-registered carriers with one or more tractors	~580,000 as of June 2025	ATA (2025)
Share of truck freight in US–Canada surface trade	67% in 2024	ATA (2025)
Federal fuel tax paid by commercial trucks	\$30.26 billion (2023 data, most recent published)	ATA (2025)
Federal diesel fuel tax rate	24.4¢ per gallon	ATA (2025)
Average state diesel fuel tax rate	31.8¢ per gallon	ATA (2025)
Carriers operating ≤10 trucks	91.5% of active carriers	FMCSA MCMIS (2023)
Carriers operating <100 trucks	99.3% of active carriers	FMCSA MCMIS (2023)
For-hire carriers with exactly 1 power unit	~70% of for-hire carriers	FMCSA MCMIS (2023)

Source: American Trucking Associations Economics and Industry Data portal (2025); Federal Motor Carrier Safety Administration Motor Carrier Management Information System (2025)

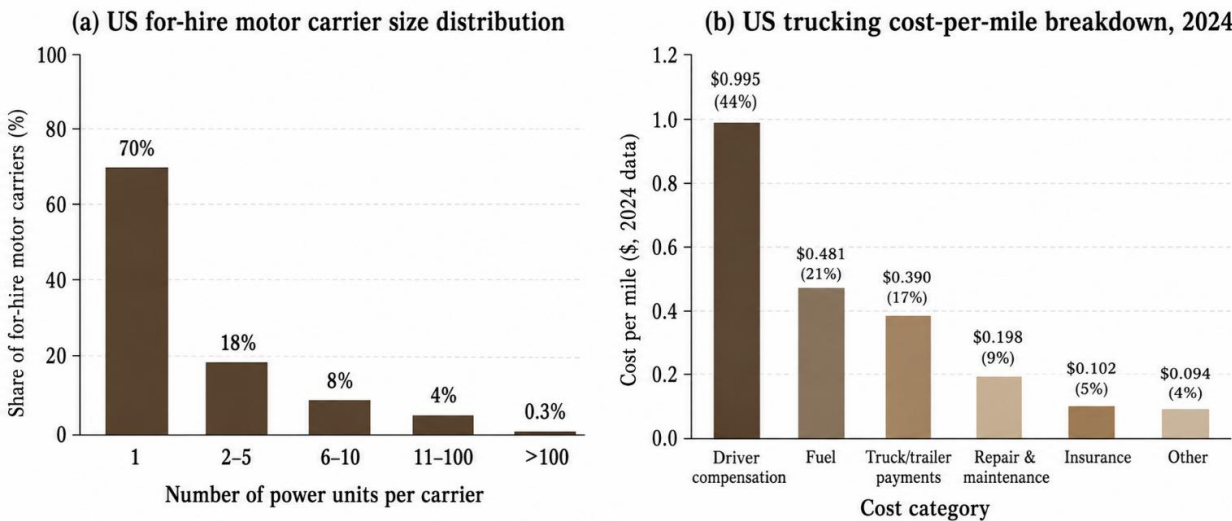


FIGURE 1 US small-carrier trucking structural and cost indicators

Panel (a) presents the size distribution of active for-hire motor carriers by number of power units, based on FMCSA MCMIS registration data as of December 2023. Panel (b) presents cost composition per mile for the industry average in 2024, based on ATRI Analysis of the Operational Costs of Trucking, 2025 edition.

Source: FMCSA MCMIS as reported through the A&I portal (2025); ATRI Analysis of the Operational Costs of Trucking 2025 edition (2025)

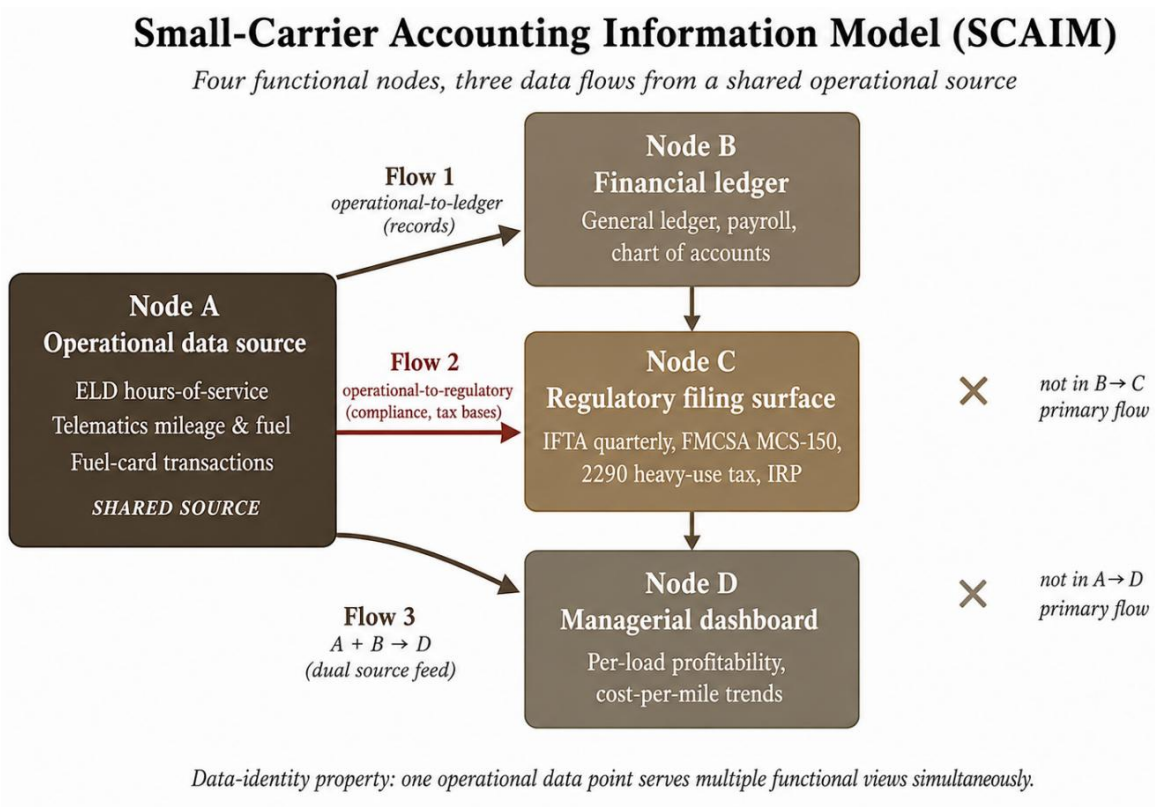


FIGURE 2 Small-Carrier Accounting Information Model (SCAIM)

Operational-data source (Node A) supplies financial ledger (Node B), regulatory filing surface (Node C), and managerial dashboard (Node D) through three flows. Flow 2 (A→C) bypasses the ledger, which is the architectural signature of the data-identity property. Absence of B→C and B→D primary flows distinguishes SCAIM from ledger-first architectures documented in Section 5.1 across retail, restaurant, and construction SME contexts.

Source: Author's development, constructed in matplotlib

at line-haul rates; fuel-card transactions become cost-of-service entries in fuel and related expense accounts. Node B outputs financial statements, tax accruals for federal and state income tax, and general-ledger reports at the frequency the accountant configures.

Node C receives Node A data through Flow 2 without transiting Node B. IFTA quarterly returns are calculated directly from telematics state-boundary crossings and fuel-card purchase-by-state records. FMCSA MCS-150 biennial updates draw from fleet-size and operational-scope data captured in dispatch and telematics systems; fleet-composition changes may trigger interim updates outside the biennial cycle. Form 2290 heavy vehicle use tax filings draw from tractor identifiers and mileage tallies; the 5,000-mile exemption threshold requires operational-data verification. Regulatory reporting under Flow 2 does not require prior posting to Node B.

Node D receives inputs from Node A directly and from Node B through Flow 3. Per-load profitability combines Node A revenue-generating events (delivered miles, load rates) with Node B posted costs (fuel expenses, driver settlement) at the load level. Cost-per-mile trend analytics combine Node A mileage

with Node B cost aggregates at the vehicle, driver, and lane level. Node D requires dual sourcing, in contrast with Node B and Node C. Node C is supported by single-source Flow 2 alone. Node D managerial view completeness requires operational data combined with posted-cost data.

4.3 Integration Quality Score matrix

Table 2 presents the Integration Quality Score (IQS) instrument. Each of the three flows is scored across two dimensions at three levels.

Score interpretation reads across the six cells as a profile, not as a composite. A carrier at same-day-and-documented across all three flows operates a mature information architecture consistent with the data-identity property. A carrier at monthly-or-longer-and-undocumented across all three flows operates a reactive information architecture in which each functional view is reconstructed independently when reports are prepared, with attendant risk of discrepancy between the four simultaneous outputs detailed in Section 4.4. Intermediate profiles identify specific flows and

TABLE 2 SCAIM Integration Quality Score matrix

Flow	Freshness dimension (lag between Node A capture and functional-view availability)	Transformation-transparency dimension
Flow 1: A → B (operational-to-financial ingestion)	<i>Same-day</i> : daily ELD, telematics, and fuel-card feeds post to ledger within business day of capture. <i>Weekly (1–7 days lag)</i> : batch upload of trip logs and fuel receipts. <i>Monthly-or-longer (>7 days lag)</i> : periodic manual reconciliation from paper or exported reports.	<i>Documented</i> : ledger rules for mileage-to-revenue and fuel-to-expense mapping specified in writing. <i>Partial</i> : rules exist informally in the bookkeeper's memory, undocumented in engagement files. <i>Undocumented</i> : mappings assembled per-transaction without stated rules.
Flow 2: A → C (operational-to-regulatory direct)	<i>Same-day</i> : IFTA-ready reports generated automatically from telematics and fuel-card data on rolling basis. <i>Weekly (1–7 days lag)</i> : aggregation from operational logs one week before filing deadline. <i>Monthly-or-longer (>7 days lag)</i> : end-of-quarter manual compilation from mileage sheets and paper receipts.	<i>Documented</i> : state-by-state allocation rules and fuel-purchase attribution rules specified in software configuration or written procedure. <i>Partial</i> : rules applied consistently by preparer but not written. <i>Undocumented</i> : allocations reconstructed for each quarter.
Flow 3: A + B → D (dual-source managerial feed)	<i>Same-day</i> : dashboard refreshes from Node A and Node B on daily basis. <i>Weekly (1–7 days lag)</i> : refresh at weekly cadence from combined sources. <i>Monthly-or-longer (>7 days lag)</i> : report preparation at monthly or quarterly cadence.	<i>Documented</i> : per-load, per-lane, and per-driver metric definitions written and reviewable. <i>Partial</i> : metrics computed on demand from ad-hoc formulas. <i>Undocumented</i> : metrics reported without derivation records.

Source: Author's development. Levels are ordinal (same-day / weekly / monthly-or-longer for freshness; documented / partial / undocumented for transformation transparency). Documentation level assessed based on presence of written rules in any format accessible to external accountant (software configuration files, engagement documentation, procedure manuals, or bookkeeping instruction files)

dimensions where remediation effort would produce the greatest improvement in overall integration quality.

4.4 IFTA illustrative case

Table 3 traces one operational data stream, telematics mileage combined with fuel-card transactions, through four simultaneous outputs required for a single quarterly IFTA cycle. Discrepancy sources are documented for each output.

Consider a carrier hauling 1,000 miles under a per-mile load contract using shipper-agreed mileage. Telematics may record 1,010 actual driven miles; IFTA state-boundary crossings may sum to 1,015 miles due to boundary rounding; driver may be paid on 998 practical miles from a standard mileage guide. Four different mileage numbers describe the same physical trip. Reconciliation between the four numbers constitutes recurring administrative work in trucking small-carrier accounting practice.

TABLE 3 Four simultaneous outputs derived from the operational data stream underlying IFTA quarterly reporting

Output	Source data used	Transformation logic	Common discrepancy sources vs other outputs
Shipper invoicing (billing miles)	Telematics dispatch-to-delivery mileage per load	Load-level total miles applied to contracted pricing structure (per-mile rate, flat rate per load, or hybrid)	May exclude deadhead miles (unloaded returns); may use shipper-agreed route mileage instead of actual driven mileage
Driver settlement (paid miles)	Telematics dispatch-to-delivery mileage per load; ELD hours for detention pay	Practical-mile calculation from standard mileage guide or telematics data at contracted driver pay rate (per-mile or percentage-of-revenue)	May use standard mileage guides (practical routing calculations) instead of telematics actual mileage; may exclude bobtail miles
IFTA quarterly return (jurisdictional miles)	Telematics state-boundary crossings; fuel-card purchase-by-state records	Total miles allocated to each state or province; fuel gallons purchased in each; net tax calculated per jurisdictional rate	Requires all miles including deadhead, bobtail, and non-revenue moves; state boundary crossings must be captured to nearest mile
Per-lane profitability analysis	Telematics mileage per lane; posted revenue and cost from Node B	Contribution margin per lane, cost per mile per lane	Uses same telematics mileage as invoicing but combined with actual (not contracted) cost basis; discrepancy from billing mileage indicates lane-level margin leakage

Source: Author's development based on FMCSA and IFTA reporting requirements (FMCSA, 2015; IFTA), ATRI industry cost data (2025), and standard trucking-accounting practice. Table 3 assumes per-mile pricing structure as the primary illustrative case; alternative structures (flat rate, weight-based) require adjusted source-data mapping. Discrepancy sources described represent typical patterns in trucking-accounting practice, not measured discrepancies from a specific carrier sample

5 Discussion

5.1 Why Data-Identity is Trucking-Specific

Retail small businesses, restaurants, and construction contractors operate under data-flow logic different from trucking. In a retail small business, the point-of-sale terminal generates a sales record that becomes a ledger entry through a Flow 1 equivalent. Same record does not simultaneously feed a jurisdiction-specific regulatory filing on the tax-basis timescale relevant here. State sales tax is reported monthly from ledger aggregates, and not calculated directly from POS transactions bypassing the ledger. Restaurant point-of-sale similarly feeds sales and inventory ledgers, with additional tip-reporting compliance flowing from payroll, and not from POS transactions directly. Construction contractors report per-project accounting with sales-and-use tax by project location, again from ledger aggregates.

In each of these contexts, regulatory reporting is a downstream projection of the ledger, which is the primary record. Node C would exist as a Flow B→C output, a reversal of SCAIM's Node C independence claim. Managerial views similarly derive from ledger aggregates, and not from a shared operational source that pre-dates the ledger.

Trucking differs because three properties combine that no other SME context combines: (a) multi-jurisdictional operation with per-jurisdiction tax base tied to physical route (IFTA), (b) federally mandated real-time operational data capture (ELD, telematics), and (c) driver compensation calculated on mileage that is also the revenue base. Any two of the three would produce a partial version. Long-haul freight without multi-jurisdiction, exemplified by intrastate carriers, removes property (a). Removing property (b) is largely historical: the December 2017 FMCSA mandate makes ELD capture near-universal for interstate carriers, and pre-mandate paper-log operations no longer characterize the current small-carrier population. Non-mileage-based payroll without ELD data feeding the paycheck, present in some LTL fleet arrangements, removes property (c). Partial versions justify a lighter architectural response than SCAIM.

5.2 Implications for AIS Design

SCAIM's Flow 2 independence implies that the traditional design principle of "ledger first, everything else derived" does not hold universally. McCarthy's REA framework (McCarthy, 1982) explicitly departs from this principle by treating economic events as the primary record; Sutton's editorial (Sutton, 2005) positions AIS research as needing to address non-standard data-flow patterns. IFTA calculations are legally definitive from operational-source data, and any ledger figures showing different mileage are

subordinate to the IFTA return. Continuous-auditing methodology (Vasarhelyi, Alles & Kogan, 2004; Chan & Vasarhelyi, 2011) assumes the ledger as the definitive record, and extension of continuous audit to trucking would need to accommodate direct A→C flows.

Big-data-in-accounting research (Warren, Moffitt & Byrnes, 2015; Alles & Gray, 2016) anticipates a shift toward larger, more granular data underlying accounting. SCAIM operationalizes this data-granularity shift for trucking specifically: Node A retains raw operational data as the primary record, with the ledger as one projection among several. Warren, Moffitt, and Byrnes (2015) anticipated measurement improvement from non-transactional data streams. Trucking exhibits an early instance of this shift: non-transactional data (ELD hours, telematics tracks) is the primary record from which transactional data (invoice, payroll entry) derives.

Operational data supplies the direct measurement basis for driver compensation and fuel costs, jointly 65 percent of per-mile total (see Figure 1 Panel b). Equipment payments, maintenance costs, and insurance premiums derive from vendor invoices and finance schedules that reference operational metrics (mileage, power-unit counts) but are not measured from operational data directly. Architectural response therefore concentrates on Flows 1 and 2, where operational data serves as direct source for both financial measurement (Flow 1) and regulatory calculation (Flow 2). Flow 3 combines outputs of Flow 1 (invoice-processed ledger data) with raw operational data at the managerial-view level.

5.3 Practical Positioning of SCAIM for External Accountants

External accountants working with US small-carrier clients (independent CPAs, part-time bookkeepers under 1099 arrangement, fractional controllership services) can apply the IQS instrument during engagement onboarding to establish baseline information-architecture profile. Same-day-documented ratings across all three flows characterize a mature client. Such a client operates fleet-management software with ELD and telematics capability (e.g., Motive or Samsara), integrated with a cloud-based or on-premises accounting stack. Monthly-or-longer-undocumented ratings characterize a client operating from spreadsheets, paper mileage logs, and end-of-quarter reconciliation, with material discrepancy risk across the four simultaneous outputs.

Assessment during engagement onboarding determines the scope of accountant intervention. A mature client with same-day cadence and documented rules requires assurance-oriented work (external accountant reviews existing rules and monitors exceptions). A reactive client with monthly-or-longer

cadence and undocumented rules requires design-oriented work (external accountant specifies rules, integrates systems, documents procedures). Profiles between endpoints require hybrid engagement scope combining rule review at documented-mature flows with rule specification at gap flows. Distinguishing these engagement types at onboarding avoids scope miscalibration.

IQS profile supports internal-control discussion with the carrier's owner-operator. Undocumented transformation rules at Flow 2 (IFTA) increase the risk of additional tax assessment during state-jurisdiction audit, because auditors cannot verify allocation methodology from source documents. IFTA member jurisdictions retain audit authority under Articles of Agreement provisions (IFTA); documentation of allocation methodology supports response to audit inquiry when it arises. Documentation gaps at Flow 2 therefore warrant priority remediation independent of numerical accuracy of past returns, with Flow 1 (ledger) and Flow 3 (managerial) documentation following as scope permits.

5.4 Limitations

Five limitations bound the present contribution.

First, this property is documented through domain-knowledge synthesis on three data types; empirical audit of a sample of US small carriers would establish the prevalence of the property in practice and the distribution of IQS profiles across the carrier population.

Second, the IFTA illustrative case is the primary continuous-cycle context exhibiting all three data-identity properties. Other periodic regulatory filings within SCAIM's architectural scope (FMCSA MCS-150 biennial updates, Form 2290 annual heavy vehicle use tax) share the data-identity structure but are less illustrative than IFTA because they operate on annual or biennial cycles, not on the quarterly cycle IFTA uses. Safety-and-compliance FMCSA touchpoints (CSA scoring, Drug and Alcohol Clearinghouse queries, DOT medical certification tracking) lack the multi-jurisdictional tax-base property and require separate architectural analysis.

Third, the architecture applies to for-hire motor carriers; private fleets (companies owning trucks to move their own goods) operate under different regulatory data-flow patterns and lie outside the present scope.

Fourth, the architecture assumes domestic US operations within the IFTA jurisdictional framework; cross-border carriers operating between the United States and Mexico, or between the United States and Canada beyond IFTA-covered provinces, face additional regulatory data-flow patterns (customs documentation, cross-border trip permits) not incorporated into the present architecture.

Fifth, the framework construction method (Section 3.5) supports architectural coherence and diagnostic utility, but not predictive claims about carrier-outcome effects; empirical validation is identified in Section 6 as a research direction.

6 Conclusions

SCAIM answers a distinctive property of US small-carrier trucking accounting that generic accounting-information-system frameworks do not accommodate. Operational data streams from electronic logging devices, telematics platforms, and fuel cards serve simultaneously as accounting-ledger inputs, as regulatory tax base under IFTA and related federal frameworks, and as managerial performance metrics on the same timescale of data capture. Four functional nodes (operational data source, financial ledger, regulatory filing surface, managerial dashboard) connected by three flows organize the architecture, with Flow 2 (A→C direct) constituting the architectural signature of the data-identity property.

Three original contributions accompany the architecture. Data-identity property is formalized through domain-knowledge synthesis on ELD, telematics, and fuel-card data types, together with specification of their multi-purpose semantic roles under US federal and interstate regulatory regimes. SCAIM structure departs from ledger-first design conventions by treating operational data as the shared record from which financial, regulatory, and managerial views project, extending McCarthy's REA event-centric approach to a specific vertical instantiation. Integration Quality Score operationalizes flow-level self-assessment across three flows and two dimensions (data freshness, transformation transparency), giving external accountants a diagnostic instrument that reads carrier information architecture from documentation available at the time of engagement.

Practical value follows from the instrument's ability to distinguish engagement types before scope-of-work commitment. External accountants receive a common vocabulary (six-cell IQS profile) for calibrating remediation priorities across trucking-accounting clients, with IFTA-side documentation gaps warranting earliest attention.

Four research directions extend the present contribution. First, empirical prevalence audit of the data-identity property in a stratified sample of US small carriers would establish the distribution of IQS profiles across the population and would identify carrier-size or carrier-type patterns in information-architecture maturity. Second, case-specific architectural analysis of additional FMCSA regulatory touchpoints (CSA scoring calculations, Drug and Alcohol Clearinghouse query cycles, DOT medical certification tracking) would clarify which touchpoints exhibit partial data-identity structure

and which require separate architectural treatment. Third, extension of the framework to private fleets and intrastate carriers with modified property sets (one or two of the three combining properties present instead of all three) would establish the boundary conditions of SCAIM's applicability. Fourth, longitudinal panel analysis linking IQS profile changes over time to carrier-outcome measures (survival, revenue per mile, IFTA audit adjustment history, safety score) would permit predictive-validity claims that the present framework construction cannot support.

7 Author's Contribution

The article presents three original contributions by the author.

First, formalization of the data-identity property specific to US small-carrier trucking. The property was articulated through domain-knowledge synthesis on three trucking-operational data types (ELD hours-of-service records, telematics mileage and fuel consumption, fuel-card transactions), each of

which serves accounting, regulatory, and managerial functions on the same timescale (see Methods, Stage 1).

Second, the Small-Carrier Accounting Information Model (SCAIM) as a four-node three-flow data-flow architecture. SCAIM was constructed through inductive instantiation of McCarthy's REA modeling primitive into a domain-specific framework (see Methods, Stages 2–3). Flow 2 architectural claim (regulatory reporting derives directly from operational data without ledger intermediation) is original to the article and constitutes the model's principal distinctive feature.

Third, the Integration Quality Score as a diagnostic instrument. The IQS in Table 2 was constructed by the author through decomposition of each flow into two dimensions (data freshness and transformation transparency) at three ordinal levels each (see Methods, Stage 4).

The IFTA illustrative case in Table 3 was selected by the author to demonstrate the data-identity property in a publicly documented setting without recourse to proprietary client information.

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