Strategies and Best Practices to Reduce Road Traffic Related to Trade in APEC Economies Using Technology and Artificial Intelligence

APEC Transportation Working Group

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List of Abbreviations

ACS	Air Cargo Community System
AI	Artificial Intelligence
AML	Asociación Mexicana de Logística y Cadena de Suministro – Mexican Logistics & Supply Chain Association
ANPR	Automatic Number Plate Recognition
APEC	Asia-Pacific Economic Cooperation
API	Application Programming Interfaces
AWS	Amazon Web Services
CBP	US Customs and Border Protection
CCTV	Closed-circuit television
CEAL	Community Emergency Alternative Response
CNN	Convolutional Neural Networks
CONPAS	Container Fast Pass
eAWB	Electronic air waybill
eBL	Electronic bill of lading
EPV	Empresa Portuaria Valparaíso
ETA	Estimated Time of Arrival
FOLOVAP	Foro Logístico de Valparaíso - Port of Valparaíso Logistics Forum
GPS	Global Positioning System
IDP	Intelligent Document Processing
IMT	Instituto Mexicano del Transporte - Mexican Transportation Institute
IoT	Internet of Things
ITS	Intelligent Transportation Systems
KPI	Key performance indicator
LabVAT	Laboratorio de Visión Artificial del Transporte – Laboratory of Computer Vision and Intelligent Transportation Systems
LiDAR	Light Detection and Ranging
LSTM	Long Short-Term Memory
MFA	Multi-Factor Authentication
ML	Machine learning
MLIT	Ministry of Land, Infrastructure, Transport and Tourism
OCR	Optical Character Recognition
ONNX	Open Neural Network Exchange
ORION	On-Road Integrated Optimization and Navigation
PCS	Port Community Systems
PDCAM	Predictive and Digital Technologies to Alleviate Congestion
R&D	Research and development
RNN	Recurrent Neuronal Networks
RTSP	Real-time video streams
SA	Simulated Annealing
SILOGPORT	Sistema Logístico Portuario - Port Logistics System
SSO	Single Sign-On
TAS	Truck Appointment Systems
TMC	Traffic Management Center
TMS	Transport Management Systems
TOS	Terminal Operating System
TOS	Terminal Operating System

TTI	Texas A&M Transportation Institute
UNAM	Universidad Nacional Autónoma de México -Mexico National Autonomous University
USDOT	United States Department of Transportation
YOLO	You Only Look Once
ZEAL	Zona de Extensión y Apoyo Logístico - Logistics Extension and Support Zone

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Background and Introduction

This project aims to bring together experts from the Asia-Pacific Economic Cooperation (APEC) economies to analyze their capacity to manage traffic in intermodal stations, seaports, airports, and borders. The focus is on identifying effective practices for minimizing waiting times in loading and unloading areas. Additionally, this project examines and suggests a technological or artificial intelligence (AI) model as a non-intrusive alternative solution to modifying or constructing road infrastructure, with the goal of reducing public spending.

Project Objectives

The project will:

1. Publicize and socialize APEC's efforts to develop, promote, and share APEC's initiatives to establish social impact methodologies, reducing travel times and CO_2 emissions in a non-intrusive way.
2. Understand the mechanisms and successful cases in using AI and other technologies in traffic mitigation
3. Analyze and improve a technological tool for traffic reduction through a non-intrusive solution.

Workshop Objectives

The workshop was a 3-day event led by Mr Juan Carlos Villa, an expert consultant who delivered a tailored program presenting the current state of the practice. The workshop served as a platform to the Laboratory of Computer Vision and Intelligent Transportation Systems (LabVAT) Methodology (Appendix I), which is a governance & collaboration model that was developed by the Mexican Transportation Institute (IMT). The IMT has been working in the development of this product since 2023, and it included a comprehensive review of literature and bibliography that is included in Appendix II.

The workshop served as an essential platform for experts, policymakers, and representatives from the private sector across APEC economies to explore and assess innovative strategies for reducing traffic in road systems adjacent to maritime ports and related to trade. This event featured a mix of research presentations and panel discussions designed to gather actionable feedback, identify challenges across sectors, and foster collaboration among the public, private, and academic communities. The goal suggests a technological or AI model as a non-intrusive alternative solution, rather than creating, modifying, or constructing road infrastructure, thereby minimizing public spending.

The workshop was held at the IMT headquarters in San Fandila, Pedro Escobedo, Querétaro, Mexico, 19-21 November 2025, and included nine keynote presentations from experts and participation from multiple economies, including Chile; Mexico; Thailand; United States; Viet Nam; and invited participants from Colombia, India, and Panama. The final workshop agenda is presented in Appendix III, and the list of participants is included in Appendix IV.

Opening Session Welcoming Remarks by Local Officials

Welcoming Remarks by Dr Alberto Mendoza, Director General of the Mexican Transportation Institute (IMT)

Very good morning. To all of you. It is an honor to give you the warmest welcome to the workshop on strategies and best practices to reduce traffic related to commerce in APEC economies, through technology and artificial intelligence. I deeply appreciate the participation of government representatives, academics, and specialists from the private sector, public organizations, local and international organizations who are with us today.

The growth of commerce in the APEC region has boosted competitiveness and economic integration but it has also generated new pressures on mobility, infrastructure, and urban sustainability. In this context, emerging technologies, particularly advanced analytics, smart transportation systems, and artificial intelligence, offer unprecedented opportunities to optimize logistical operations and reduce congestion.

Improve road safety and minimize environmental impact. I am sure that the exchange that begins today will be of great value for everyone. The ideas, analyses, and proposals that emerge will help build safer commercial corridors, smooth, sustainable, and resilient, in line with APEC's priorities for inclusive and smart growth.

I invite you to participate actively, share your experience and make the most of this space for dialogue and collaboration.

Without further ado, I officially declare this workshop open, and I wish you a productive and enriching day. I especially thank José Antonio Anguiano Breña, Sub-coordinator of Infrastructure for the State Infrastructure Commission of the Executive Power of the State of Querétaro, for being with us today.

Welcoming Remarks by José Antonio Anguiano Breña, Sub-Coordinator of Infrastructure, State Infrastructure Commission, Government of the State of Querétaro

Thank you very much. Good morning. Receive a warm greeting from Governor Mauricio Curi, who unfortunately was not able to attend the invitation for today. At the opening of this international workshop, APEC, Mexico 2025.

Road safety is one of the most concerning issues worldwide and affects society as a whole: population growth and urban sprawl are causing the number of vehicles on the roads to increase every day, which underscores the importance of addressing these challenges and seeking innovative and effective solutions to improve safety.

In this context, artificial intelligence has become a decisive tool for addressing some of the most important challenges of the last decade. The area of transportation systems and communication routes has not been an exception. By optimizing routes, improving traffic control, strengthening safety measures, and revolutionizing the construction and maintenance of infrastructure, artificial intelligence contributes to a more eco-friendly, efficient, and safe transportation ecosystem.

This includes driver-assistance systems and the use of autonomous vehicles, among other applications.

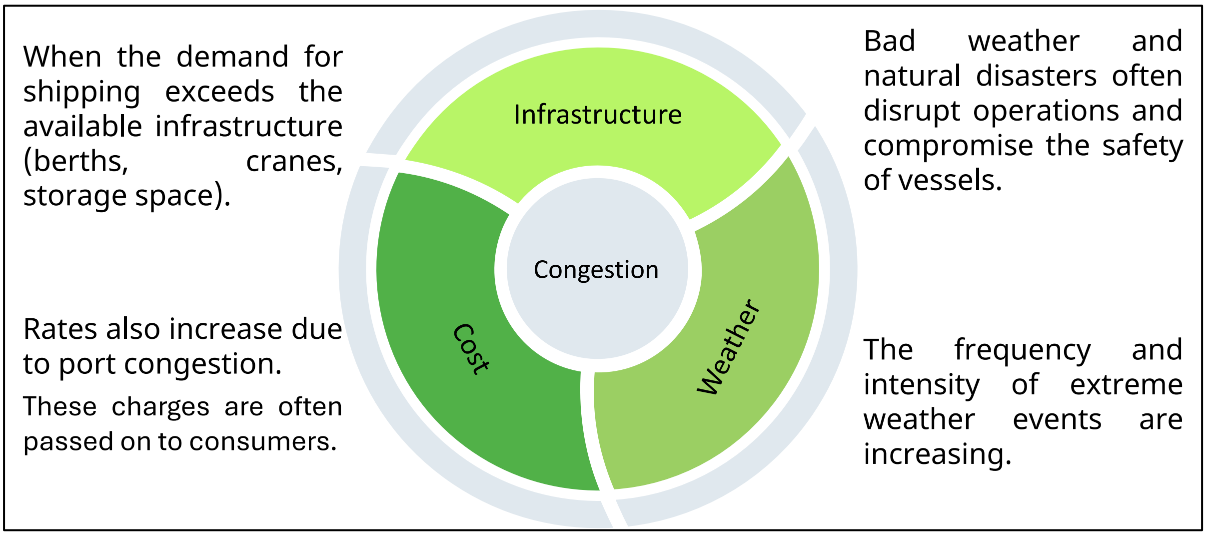
This demonstrates the potential of artificial intelligence to save lives and reduce injuries on roadways. As can be seen, the potential of artificial intelligence is very broad and, as it continues to evolve, its transformative impact on sustainable transport will become increasingly evident.

SESSION I OVERVIEW OF APPROACHES AND METHODOLOGIES FOR TRAFFIC REDUCTION

Non-automated strategies for efficient vehicular flow management by Dr Ricardo Montoya, Autonomous University of Querétaro

Dr Ricardo Montoya opened by asserting that non-automated, human-centered logistics strategies are far from obsolete; rather, they constitute the practical foundation on which automated and AI-driven systems are built. The pandemic exposed critical fragilities in global supply chains, unequal vaccine distribution, semiconductor shortages for vehicles, and severe congestion at ports that left vessels anchored offshore while trucks and trains queued for access. These events did not only reveal capacity shortfalls but also showed how, in the absence or failure of digital systems, traditional operational practices remained essential to keep goods moving. Montoya stressed that even as ports and terminals advance toward automation, many regions lack the digital infrastructure to support it, and climate-related disruptions (fog, storms, hurricanes) will periodically force a return to manual operations. Thus, understanding and refining non-automated strategies remains a practical and strategic priority. The following graphic illustrates the congestion at ports and maritime terminals.

Graphic 1. Congestion at Ports and Maritime Terminals



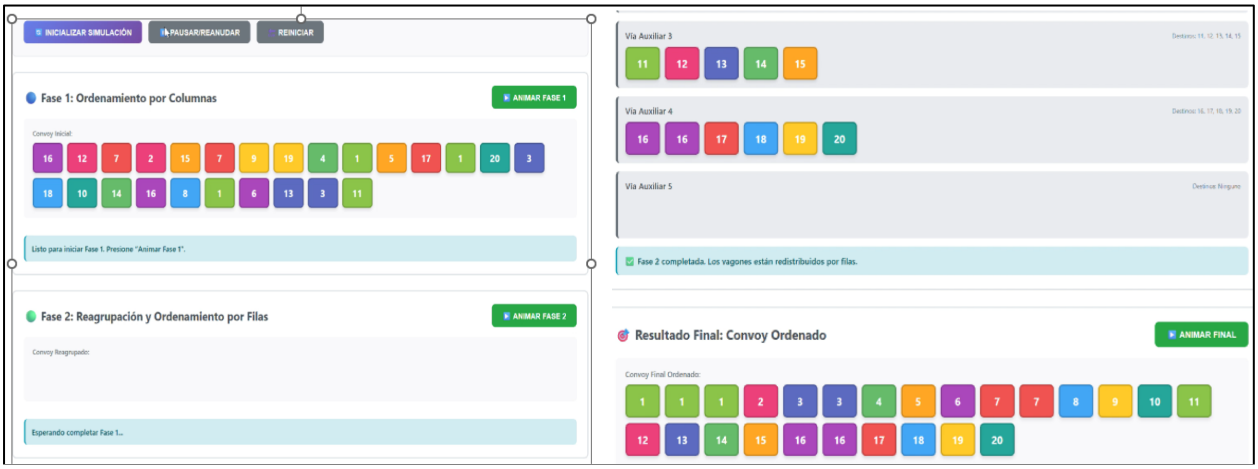
He described four practical methodologies commonly used by human operators and illustrated how each provides immediate value yet presents limits that make them natural inputs for future automation. The first, appointment-based time windows for carrier arrivals, is widely used because it is simple and low-cost: terminals coordinate shipment, loading and unloading times by phone, email or messaging apps. Time windows reduce idling and queueing with minimal investment, and their flexibility enables quick local adjustments. However, Montoya emphasized the trade-offs: records are decentralized (notes, logs, inboxes), real-time situational awareness is weak, and scheduling quickly becomes unmanageable as volumes grow from dozens to hundreds or thousands of trucks. Human error, memory limits and potential favoritism also introduce biases and inefficiencies that cannot scale without digital support.

The second common practice, manual platform assignment for incoming vehicles and containers, relies heavily on the experience and heuristics of dispatchers and crane operators. For small-to-moderate operations this can be effective, but Montoya highlighted evidence from the literature showing that mathematically driven heuristics and optimization models consistently outperform manual allocation in cost and throughput when scale and complexity rise. Manual methods therefore serve as immediate stopgaps and repositories of operational knowledge, but without digitization they resist consistent replication and performance auditing.

Montoya's deeper technical examples explored two classical combinatorial problems that operators have long solved with practical heuristics: pre-marshaling (rearranging container stacks so high-priority units are accessible) and train reordering using auxiliary tracks. In pre-marshaling, the goal is to position containers so those that must load first are not blocked by lower-priority boxes above them. He described Gate's heuristic and similar rules-of-thumb that operators use to minimize extra moves. Each additional repositioning entails real cost and delay, and while the pre-marshalling problem admits polynomial-time solutions in formal terms, it grows computationally intensive with large stacks and many priorities. The human heuristics used today effectively reduce immediate friction but leave a quantitative gap that automated planning and AI can later exploit by analyzing moves, predicting priorities, and planning fewer rehandles.

The train reordering example was presented as an elegant yet low-tech matrix-transposition heuristic using auxiliary tracks. Operators first distribute cars by columns across auxiliary routes (so destinations are grouped), then perform a second pass to reorder by rows, producing a sequence suited to progressive deliveries with minimal shunting. Montoya explained the square-of-routes relationship, three auxiliary tracks let operators realistically reorder up to nine destinations, five tracks up to 25, and showed how the technique's simplicity facilitates human execution even as the combinatorial complexity grows and approaches NP-hard territory. He noted that code and visualizations for these heuristics are available for operators and planners who want to experiment with destination mixes and routes. The following figure depicts the first and last steps of the sorting rail car process.

Graphic 2. Sorting Rail Car Process



Throughout the talk Montoya argued that these non-automated practices should not be discarded but rather captured, formalized and digitized so they can feed into AI training and hybrid operational architectures. When autonomous equipment (such as Busan's autonomous yard tractors) and real-time tracking are available, they bring considerable benefits: continuous visibility of container positions, timestamps for moves, and data to optimize flows. Yet autonomous systems themselves learn faster and behave more reliably when their initial policies and constraints reflect the real-world heuristics operators use and the operational nuances that are not obvious from raw sensor feeds. Moreover, embedding human-derived constraints helps avoid dangerous or inefficient automated behaviors and reduces the risk of encoding human biases uncritically. Montoya cautioned that automation could amplify favoritism or suboptimal local rules if those are not explicitly corrected during model training.

He closed by reinforcing a practical, phased approach. In regions with limited digital infrastructure, non-automated strategies remain indispensable for immediate resilience and equitable access to trade. In mixed environments, hybrid operations, humans and automated systems coexisting with clearly defined responsibilities and failover modes, offer the best path to reliability. Importantly, the data produced by even low-tech methods (time-window schedules, paper logs of platform assignments, recorded crane moves) are valuable: they create historical datasets for process mining, permit incremental automation, and provide benchmarks to evaluate the performance uplift from AI-driven scheduling and routing. In short, Montoya framed non-automated strategies not as relics but as living, transferable expertise that should be catalogued, digitized, and incorporated into the design of AI and automation to ensure robust, scalable and fair improvements in cargo flow and trade-related road traffic.

Predictive and Digital Technologies to Alleviate Congestion in Maritime Port Logistics: Strategic Frameworks across APEC Economies by Dr Bertha Martínez, CETYS Universidad + Mexican Logistics & Supply Chain Association (AML)

Dr Bertha Martínez framed predictive and digital technologies as practical and urgent tools to relieve chronic congestion in maritime port logistics across APEC economies, emphasizing that these tools shift ports from reactive firefighting to anticipatory, coordinated operations. She highlighted that APEC's ports are diverse in capacity and readiness but united by the Pacific trade flows they support: together the 21 economies account for roughly 62% of global GDP and nearly half of world trade, and over 60% of global container throughput passes through APEC ports.

She reinforced that APEC is not only a high-volume region, but also a uniquely complex operating environment where congestion has become a systemic risk: highly connected maritime networks and redistribution hubs amplify volatility, and vessel upsizing has intensified inland peaks—concentrating truck flows into tighter discharge windows that strain gates, yards, and port–city corridors.

That scale means improvements in visibility, predictability, and coordination across APEC deliver outsized global benefits and support the workshop objective of reducing trade-related road traffic through technology and artificial intelligence. The following graphic provides a summary of the Predictive and Digital Technologies to Alleviate Congestion (PDCAM) in Maritime Port Logistics.

Graphic 3. PDCAM Framework

PDCAM Framework

Layer 1 – Physical Infrastructure
Ports, terminals, gates, yards, corridors

Layer 2 – Digital Systems
PCS/TOS platforms, IoT sensors, real-time dashboards, e-documents

Layer 3 – Predictive Intelligence
ETA models, congestion forecasting, dynamic slot optimization

Layer 4 – Governance & Coordination
Multiagency cooperation, regulatory alignment, data-sharing agreements

A holistic model to synchronize port–hinterland operations across APEC economies.

Martínez opened by describing the operational realities that make prediction essential: vessel arrival deviations commonly range from six to 18 hours, inland and maritime constraints can cascade rapidly across time zones, weather and geopolitics create sudden route changes, and manual, paper-based coordination cannot keep pace with volatile demand. She noted that congestion today is often not caused by a lack of physical assets but by insufficient real-time synchronization among stakeholders—a coordination shock driven by asynchronous information, siloed data, limited pre-clearance, and outdated documentation and inspection workflows. She described vessel bunching as a primary trigger, compressing demand and overwhelming terminal and landside processes when arrival patterns collapse into a single peak window.

She connected this to persistent procedural bottlenecks such as paper-dependent release processes, sequential verifications, and fragmented clearance that slows down gate cycles and amplifies queue formation. The message was that these frictions are predictable failure modes that emerge when maritime variability meets landside rigidity—exactly the conditions that predictive analytics and interoperable digital platforms are designed to mitigate.

Graphic 4. Operational Realities at Maritime Ports

Vessel bunching creates sudden truck surges
Irregular arrival patterns compress discharge operations and generate intense, unplanned peaks in truck demand that overwhelm gates, yards, and port–city corridors.

Asynchronous and paper-based documentation
Manual workflows and non-digital clearance processes slow vessel release, delay customs coordination, and trigger queue formation at terminal gates.

Limited pre-clearance and manual inspections
Insufficient electronic pre-processing forces inspections and verifications to occur post-arrival, creating unpredictable processing times and operational bottlenecks.

Siloed information across stakeholders
Terminals, customs, trucking companies, and regulators often lack real-time data exchange, resulting in fragmented decision-making and inefficient resource deployment.

Gate operations without dynamic sequencing
Static appointment windows, manual booth procedures, and the absence of predictive load balancing limit gate throughput and reduce system resilience during peak flows.

Urban congestion amplified by port traffic
At the port–city interface, intersections, signal cycles, and last-mile corridors become critical chokepoints, especially during high-volume discharge windows in dense APEC metropolitan areas.

To address these frictions, Martínez proposed a layered, pragmatic model in which physical capacity is necessary but insufficient: digital systems must provide shared real-time visibility, predictive intelligence must convert data into reliable foresight, and government institutions must enable data sharing and cross-agency coordination. Predictive technologies—estimated time of arrival (ETA) forecasting using AIS and weather inputs, machine-learning demand forecasts, staffing and gate-allocation forecasts, dynamic slot optimization, and bottleneck anticipation for yards and access roads—turn uncertain futures into actionable timelines.

Digital technologies—port community systems, appointment and slot booking platforms, terminal operating systems, electronic documentation such as e-B/L, Internet of things (IoT) visibility tools, OCR and computer vision for gate automation, integrated dashboards, and digital twins for corridor simulations—turn foresight into coordinated operational actions by all stakeholders. She stressed that these layers are complementary: prediction without timely data-sharing yields no operational impact, and digitization without predictive models leaves ports reacting to events rather than anticipating them.

She further emphasized that effective implementation depends on interoperability, enabling shipping lines, terminals, customs, trucking companies, logistics operators, and related agencies to share a unified operating picture. Standardized APIs and shared real-time dashboards were highlighted as practical enablers so that updated ETAs, yard-density alerts, or gate-capacity changes trigger synchronized responses rather than fragmented reactions across the system.

Concrete port examples underscored feasibility and impact. Appointment systems integrated with predictive ETAs have reduced peak gate queues by up to 30% in some terminals; Busan's appointment and yard systems and Singapore's AI-driven port orchestration illustrate improvements in throughput and reliability; and Los Angeles/Long Beach's Port Optimization Platform demonstrates the value of end-to-end visibility for cargo flows.

Martínez also described initiatives to reduce port–city congestion by shifting containers off congested truck corridors onto rail corridors and dry ports—an approach in which predictive routing and scheduling can relieve local road pressure while improving corridor-level fluidity. She argued that even modest digital pilots—slot booking, basic ETA forecasting and dashboarding, and early-stage corridor simulations—deliver operational benefits and generate the data foundation needed for broader transformation.

Graphic 5. Proposed Platform

From a regional perspective, Martínez highlighted digital and institutional barriers. Many APEC ports face infrastructure strain as nearshoring and rising trade volumes push operations closer to capacity limits; others lag in intermodal integration and multi-agency processes. Data silos, reluctance to share commercial or customs information, uneven regulatory frameworks, and gaps in digital skills hinder cross-border coordination. She urged governments and port authorities to modernize regulations to enable paperless trade, standardize data schemas, and prioritize multiagency digital trust frameworks that allow secure information exchange. Training and capacity building were positioned as equally important: future logistics professionals must manage using data and tools, and staff must be prepared to interpret predictive outputs and act on early-warning signals.

Her roadmap proposed pragmatic sequencing aligned with port maturity stages—digitize, integrate, orchestrate—starting with short-term pilots (appointment systems, basic ETA forecasting and dashboarding, and rapid digitalization of core trade and customs documentation), progressing to mid-term integration (Port Community Systems-PCS – Terminal Operating Systems- TOS connectivity, expanded predictive staffing and gate allocation, and digital twins for yard and corridor planning), and advancing to longer-term orchestration (corridor-level synchronization, standardized cross-border data sharing, and AI-enabled optimization across terminals).

She emphasized that full automation is not the immediate objective for every economy; rather, the objective is to scale progressively so that physical investments are amplified by synchronized operations, interoperability, and governance. Importantly, she framed efficiency gains as environmental wins: fewer idling trucks and fewer unnecessary moves reduce emissions, aligning port performance with sustainability and resilience goals.

Martínez concluded with a call to action tailored to APEC: scale regional pilots, harmonize data standards, strengthen public–private collaboration, adopt paperless trade and customs modernization, and invest in digital trust and multiagency governance. Key takeaways emphasized that

(1) predictive analytics improves operational readiness by converting volatility into actionable lead time,
(2) digital platforms enable shared visibility and coordinated execution, and

(3) interoperability and governance are essential to scale benefits across stakeholders and corridors.

Her central message was that predictive models and digital platforms are no longer aspirational technologies but essential enablers of resilience and competitiveness; when combined and institutionally supported, they let ports anticipate congestion, allocate resources proactively, and translate volatile global signals into coordinated local action.

Discussion Session I

Mr. Juan Carlos Villa led the discussion and Q&A session after the first two presentations that developed into a conversational, operational exchange between presenters and participants.

The discussion started by stressing that demand currently exceeds capacity at many seaports, recommending that port authorities first review their master plans, because ports are typically expanded incrementally and decisions about land, staged growth and financing determine long-term capacity. Urging authorities to define clear problem statements and work backwards from desired outcomes before selecting optimization models or off-the-shelf algorithms.

A participant asked what "NP-hard" means in the context of optimization. Mr Montoya explained that NP-hard problems grow in computational difficulty as variables increase; exact solutions become impractical at scale, so practitioners use heuristics and approximation methods to obtain near-optimal answers quickly.

Dr Martinez, who reported port delays of five to eighteen hours, was asked to clarify "AIS." She explained AIS in the maritime context is the Automatic Identification System used to track vessel positions (distinct from aviation's Airport Information Services).

William Rojas from El Dorado Airport raised a practical question about predictability: given long maritime transit times and the slow, complex nature of vessel operations, how much can forecasting actually reduce congestion? Respondents agreed that predictability matters precisely because vessel schedules are planned far in advance and changing routes or berthing is costly and disruptive. Accurate early warnings and better visibility let operators reassign containers, replan truck movements, and manage scarce berth and yard capacity—so forecasting is useful even when transit horizons are long.

A participant from Colombia asked about empty-container flows and reverse logistics. The room acknowledged this is largely an infrastructure and commercial-incentive problem (yard space, container repositioning, carriers' commercial choices). Several speakers noted that AI can contribute, by improving forecasting, optimizing repositioning and suggesting prioritized routing, but that technical fixes must be paired with yard investments and contractual or market incentives.

There was a practical exchange about paperless processes. One attendee described a lean, QR-based workflow observed in Guadalajara; Bertha and others replied that Mexico does have digital systems but frequent customs system failures force operators back to paper. Participants emphasized the need to improve system reliability and resilience so paperless processes can be sustained.

Juan Marcos Macía described visits to highly automated ports in the People's Republic of China and asked whether full automation should be the goal. Presenters responded that full automation yields enormous throughput but requires scale, capital, and institutional readiness not available everywhere. They recommended focusing first on achievable digital steps—appointment systems, ANPR/OCR gates, simple computer-vision deployments, and port community systems—before pursuing full automation.

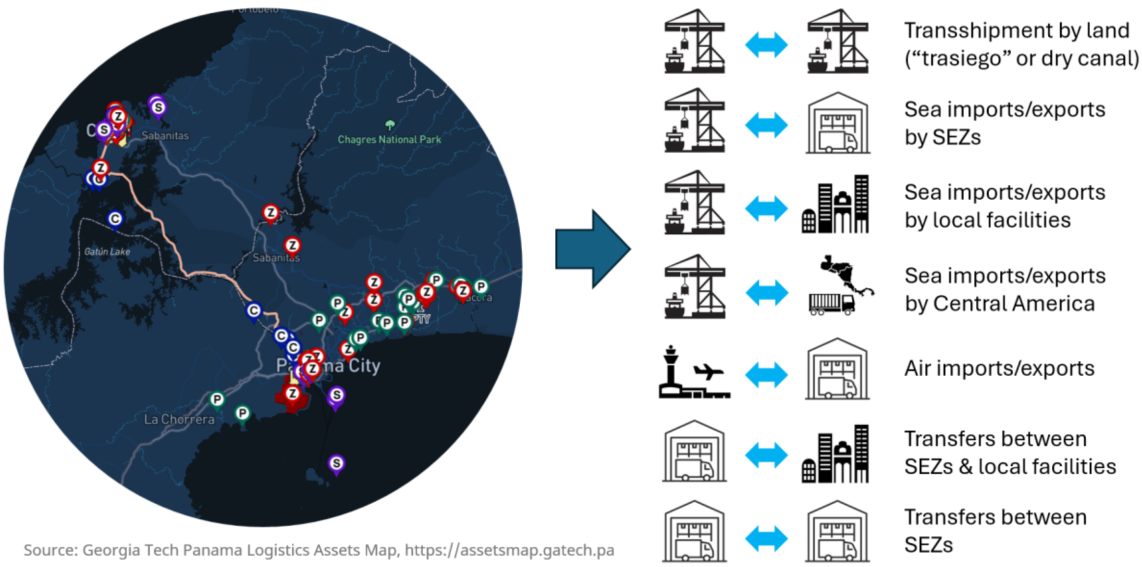
Throughout the discussion several practical recommendations recurred: define explicit problem statements and KPIs before choosing tools; inventory master plans, land and funding constraints; start with low-risk digital steps that deliver immediate operational value; use heuristics for large NP-hard scheduling problems with human-in-the-loop controls; and pair AI/optimization with necessary infrastructure investments and governance to ensure reliable, paperless operations.

SESSION II OVERVIEW OF TECHNOLOGIES AND ARTIFICIAL INTELLIGENCE FOR TRAFFIC REDUCTION

Synchronizing Panama: Seamless Flow at the Bi-Oceanic Intermodal Hub by Dr Jorge Barnett, Georgia Tech Panama Logistics Innovation & Research Center

Dr Jorge Barnett framed Panama's logistics challenge around a three-dimensional interface—physical, digital, and human—and used that lens to show why technology must be thoughtfully synchronized with place, processes, and people at the economy's bi-oceanic intermodal hub (Graphic 6).

Graphic 6. Flow characterization in the Panama Bi-Oceanic Intermodal Hub



Source: Georgia Tech Panama Logistics Assets Map, https://assetsmap.gatech.pa

Panama's outsized role as a maritime and air crossroads (high passenger volumes, major transshipment activity and growing SEZ/logistics parks) concentrates many flow types into a small geography: about 30% of containerized cargo transits the economy by land ("dry canal"), a large share of air cargo and many sea-to-air movements must cross the same urban corridor, and a rising rail and SEZ footprint will further concentrate activity around the canal area. Those characteristics produce intense, recurring peaks at port gates and convoys of trucks that exit and re-enter terminals in large batches, creating severe first-/last-mile congestion even where the underlying flow processes are low complexity.

Barnett stressed that not all flows are the same: port-to-port dry-canal moves are high-intensity but low complexity; SEZ interactions introduce medium complexity because of dual customs/authority touchpoints; final imports are low-intensity but high complexity because of fragmentation and many agency interactions. These distinctions explain why congestion manifests at different points—gates, customs clearance yards, and local roads—and why digitizing a process is not enough if the underlying institutional workflows still require manual stamps or constrained office hours (Graphic 7).

Graphic 7. Interaction matrix for the Panama Bi-Oceanic Intermodal Hub

	Complexity	Intensity	Outcome
Transshipment by land ("trasiego" or dry canal)	Low	High	Congestion in port gates
Sea imports/exports by SEZs	Medium	Medium	Congestion in customs clearance zones and access corridors
Air imports/exports			
Transfers between SEZs			
Sea imports/exports by local facilities	High	Medium	Congestion in local roads
Sea imports/exports by Central America			
Transfers between SEZs & local facilities			

On technologies, Barnett emphasized that AI is a method—not a magic switch—and should be embedded in an optimization framework that respects human behavior and institutional realities. He reviewed technologies in order of practical adoption and acceptance in Panama: biometric/automated truck recognition and accelerated document processing (widely adopted during the pandemic); RPA/chatbots and WhatsApp-based interfaces (high human acceptance when designed around truckers' habits); gate appointment systems and truck sequencing (mixed results; adoption hampered by fragmented small carriers and behavior); drones for perimeter and yard surveillance (limited by airport proximity and regulations but useful with permits); yard automation and remote crane operations (some terminals already deployed yard automation); autonomous vehicles (promising but constrained by regulation, labor concerns and cost); and pervasive cybersecurity (urgent because integrated visibility increases attack surface and AI-enabled threats like AIS spoofing are real).

Practical human-centered lessons stood out: trucker adoption is driven less by technical sophistication than by usability and trust—simple WhatsApp chatbots outperform complex web portals. Gate appointment systems show benefits but require coordinated incentives and education for many small operators. Pilots must consider unions, regulatory readiness and the social consequences of automation. Barnett also warned that government systems often lag private evolution; rigid, monolithic government deployments can become obsolete quickly, so solutions must be modular, interoperable and upgradeable.

Cybersecurity emerged as a core operational constraint: as port community systems, TOS and carrier systems become tightly integrated, spoofing and probing attacks (e.g., AIS manipulation) can create false visibility and cascade into operational failures. Panama's ports have formed task forces and are exploring AI tools for defense, but defensive planning must accompany any expansion of data sharing or automation.

Barnett's operational recommendations were pragmatic and systemic: treat the economy as a hub (a “hub community system” rather than isolated port PCS, prioritize interoperability and secure data exchange across terminals, carriers, airports and customs, and design robust adaptive systems that can evolve with private sector change. He urged technology choices that match flow types (e.g., optimize gate sequencing for dry-canal convoys; streamline multi-agency digital processes for final imports) and recommended human-centric deployment paths—use low-friction interfaces (WhatsApp/chatbots), stage pilots where benefits and incentives align, and build cybersecurity and governance in from day one.

Digital Corridors and Logistic Hubs by Mr Raúl Suárez, Kale Info Solutions

Mr. Raúl Suárez described Digital Corridors and Logistic Hubs from a practitioner's view focused on Colombia's perishables (notably flowers) and airport logistics, emphasizing practical barriers to digitization and the high payoff of end-to-end data sharing.

Suárez opened with a concrete problem: airport export workflows remain paper-intensive despite available standards (e.g., eDocket, e-Air waybill-eAWB, electronic bill of lading-eBL). In Bogotá drivers routinely carry multiple paper bundles—one per airway bill/handling agent—creating long queues and delays that slow the entire perishables cold chain. The root causes he identified are regulatory requirements that still mandate paper, fragmented institutional practices, and low adoption among frontline operators (small truckers who resist complex portals). Even where digital systems exist, government or agency processes (manual stamps, office hours, unreliable customs systems) force reversion to paper, so mere digitization without process change yields limited gains.

He framed digital corridors as a solution: if source data (master/daughter waybills, cargo content, handling instructions) is entered once and shared across actors, manual re-entry disappears and document handling time can fall dramatically (he estimated 80–90% reductions in repetitive data entry). Digital corridors deliver measured benefits for speed, reliability and carbon footprint by eliminating redundant steps across origin, gateways and destination.

Practical technologies and deployment lessons Suárez highlighted:

- Adopt standards already available (IATA eAWB, eBL) and integrate with local regulatory processes so electronic documents are legally accepted.
- Use low-friction interfaces for truckers (WhatsApp/chatbot front-ends, photo uploads) rather than forcing them onto complex web portals.
- Implement interoperable platforms (PCS/TOS) links, maritime tracking services) and reuse proven commercial services (e.g., Marine Traffic for ETA visibility).
- Focus on human and institutional change: regulators change frequently, and political turnover delays continuity; therefore, prioritize pilotable steps that show quick wins and build trust with authorities.
- Leverage AI/automation to speed document validation and forecasting once legal acceptance and data quality problems are solved.

Barriers and policy points:

- Heterogeneous legal frameworks across Latin American economies prevent seamless corridor deployment; harmonized regulatory standards are needed regionally.
- Institutional inertia and changing officials make multi-year projects fragile; simpler interoperable building blocks and political engagement are critical.
- Cultural and operational realities of trucking—fragmented, often one-person operators—require design that minimizes data burden on drivers.

Suárez's practical roadmap: start by integrating and standardizing existing platforms and standards, pilot end-to-end electronic document flows for perishables (where speed and product value justify urgency), deploy low-friction trucker interfaces, and concurrently work with regulators to accept electronic documents and signatures. Once consistent digital exchange is established, apply AI/RPA to automate validation, forecasting, gate sequencing and other optimizations.

Digital Flightpath Toward Competitiveness, by Mr William Javier Rojas Moreno, EL Dorado Airport

El Dorado Airport ranks 34th globally (ACI) and faces a pressing need to boost throughput and competitiveness despite constrained infrastructure and rapid demand growth. Congestion at El Dorado Cargo Terminal primarily arises from the need to balance three interdependent domains: airside capacity (aircraft handling and parking), warehouse throughput (processing and staging cargo), and landside operations (truck arrivals, gate processing, and road access). The airport processes roughly 2,000 truck movements daily and about USD1 billion monthly in international trade for Bogotá; inefficiencies in dwell time on the landside, slow warehouse turnover, and fragmented stakeholder workflows translate directly into higher freight costs (air freight up to approximately USD1,400 per ton) and reduce competitiveness.

A value-chain perspective underpins the airport's strategy: identify each stakeholder's critical KPIs, measure the economic cost of dwell time, and prioritize interventions that reduce delay and cost per value chain (perishables, e-commerce, high-value manufacturing). Perishables and break-bulk handling limit immediate automation because manual handling remains essential for quality control; Latin American manual throughput (≈0.5–0.8 t/hr/man) contrasts sharply with automated hubs (≈3.5 t/hr/man), revealing the productivity gap and technology opportunity.

Key constraints and cross-cutting enablers

- Legacy infrastructure and data silos: disparate systems across handlers, customs and carriers impede end-to-end visibility.
- Workforce capability: logistics skills are uneven; workforce training and retention are necessary to realize technological benefits.
- Governance and data sharing: public–private trust barriers slow data exchange and joint optimization; privacy and commercial sensitivity remain concerns.
- CAPEX and phased adoption: high upfront costs for IoT/automation require staged pilots to demonstrate ROI.

Practical technology interventions (short → long horizon) Short-term (quick wins)

- RPA and automated document workflows: reduce manual paperwork and accelerate customs/handling validation.
- Video analytics & geofencing: detect gate congestion, track dwell times, enforce SOPs and improve safety.
- Chatbots/low-friction trucker interfaces (WhatsApp integration): increase frontline adoption and reduce gate dwell without imposing complex portals.

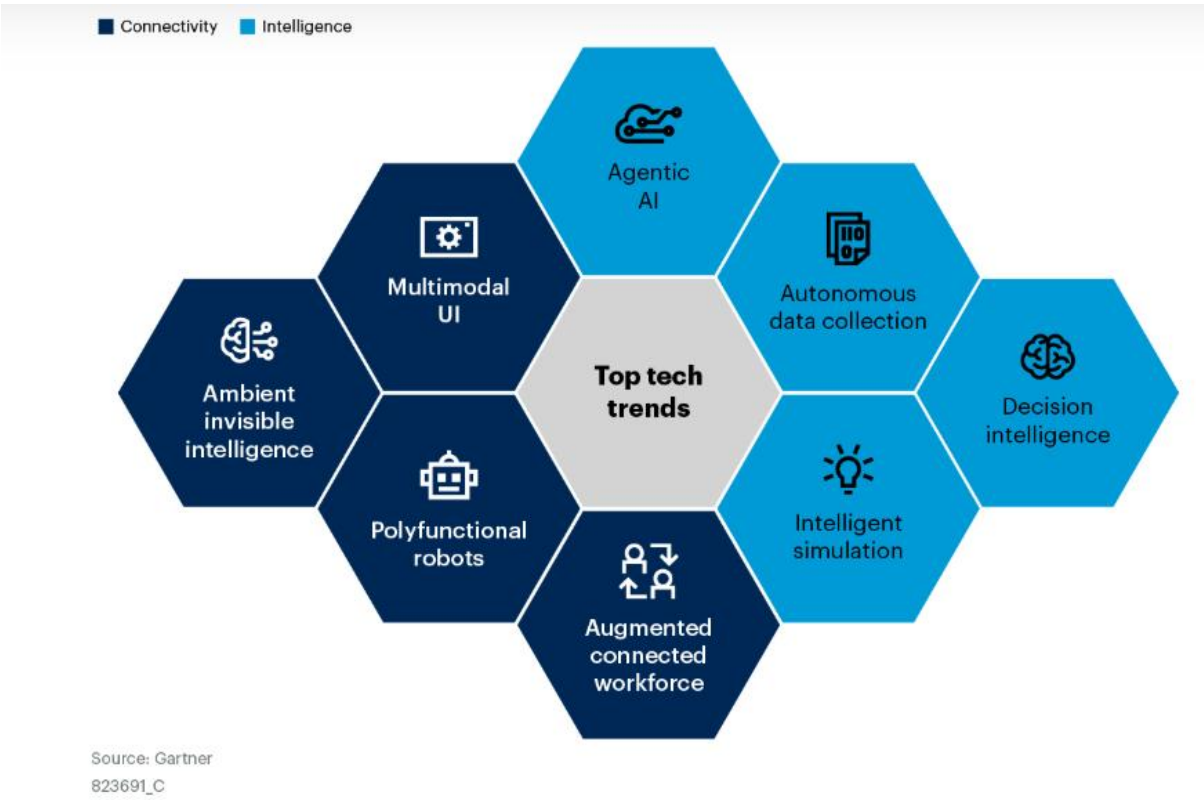
Mid-term (operational optimization)

- Integrated Air Cargo Community System (ACS) / PCS–TOS linkages: break silos and enable consistent master/daughter waybill propagation and status updates.
- Predictive demand & resource planning: forecast peak windows, align staffing and apron/warehouse allocation, minimize convoy peaks.
- Digital twins for scenario testing: model peak demand, reroute capacity and assess investment tradeoffs in a virtual environment.

Long-term (transformational)

- IoT and automated handling/robotics where feasible: raise throughput per worker for non-sensitive cargo; targeted automation in warehousing.
- Automated cargo profiling & pre-clearance (customs): enable green-light workflows and reduce processing time on arrival.
- Advanced route/road optimization (last-mile AI): reduce vehicle miles, emissions and urban congestion linked to airport freight.

Graphic 8. Top Trends in Supply Chain Technology for 2025



Source: Gartner Identifies Top Supply Chain Technology Trends for 2025, March 18, 2025

Operational KPIs and economic linkage Integrate AI outputs into measurable KPIs tied to economic impact: minutes of dwell time → landed cost per ton → domestic competitiveness metrics. Use short pilots to quantify savings and then scale. For example, improved gate sequencing and low-friction driver check-in can reduce peak convoy formation and lower average truck dwell by measurable minutes, which translate directly into cost and carbon savings.

Workforce and change management

- Invest in logistics training programs regionally to raise baseline capability (benchmarked to Miami and other hubs).
- Phase automation to preserve jobs and retool roles; emphasize human–AI collaboration (operators supervising automated systems).
- Use demonstrable pilots to build trust with unions and regulators.

Governance, data trust and public–private collaboration

- Establish secure data-sharing frameworks and agreements to protect commercial sensitivity while enabling operational coordination.
- Pilot paperless trade (eAWB, eDocket, eBL) with regulatory sandboxes to build legal acceptance and continuity despite political turnover.
- Co-develop KPIs with customs and handlers to align incentives for pre-clearance and green-light profiling.

Use cases and benchmarks

- Road/route optimization (UPS On-Road Integrated Optimization and Navigation -Orion): large mileage and emissions savings from routing and optimization.
- Digital twins and predictive maintenance: simulate capacity scenarios and reduce unscheduled downtime.
- Automated cargo classification and customs profiling (benchmarks from Brazil): enables pre-arrival clearance and reduces arrival processing.
-

Environmental and competitiveness co-benefits

Reducing idling and unnecessary moves improves sustainability (lower emissions) while decreasing landed costs for exports and imports. Linking operational KPIs to domestic trade competitiveness (e.g., cost per ton, time to market for perishables) helps prioritize investments. Promoting and training the companies at "C level" in driving rapid AI adoption in supply chains through proven short-term wins and best-practice implementation. Specific recommendations include:

- Automated integration (avoid silos)
- Data analytics – business analytics (decision making – alternate scenarios)
- RPA (critical tasks increase supervision)
- Predictability – demand & resource planning (balance capacity)
- Customs application: profiling (workflow consistency)
- Video analytics application to identify operational coordination (safety & security)
- Digital twins (virtual planning environments for predictive accuracy)

Recommendations and phased roadmap

1. Short term (0–12 months): implement low-friction driver interfaces (WhatsApp), deploy video analytics and RPA for paperwork, and run targeted pilots to measure dwell reductions and ROI.

2. Mid-term (12–36 months): integrate community systems (ACS/PCS–TOS links), deploy predictive staffing & appointment sequencing, and build digital twins for investment testing.

3. Long term (36+ months): scale IoT and selective automation, implement customs pre-clearance profiling, and institutionalize governance and data trust frameworks.

Discussion Session II

In the second discussion session, Carson Poe opened the Q&A by asking who is developing the predictive AI tools, what assumptions they're built on, and what inputs they require. He cautioned that transparency is essential, so these tools don't disadvantage particular sectors. The group agreed that this question must remain central as systems scale.

A participant asked Jorge Barnett about drone use beyond security, specifically for deliveries or documentation transfer to ships. Jorge Barnett replied that ports are piloting drones chiefly for diagnostics and inspection (locating misplaced containers, structural checks with LiDAR, and crane maintenance). He noted a few firms are testing parts delivery to anchored vessels, but regulation is the main barrier: maritime authorities lack drone-delivery licensing, airport no-fly zones restrict operations, and carrying people by drone raises major safety and legal issues. The consensus was that drones are promising for data collection and selective deliveries, but broad operational use awaits regulatory frameworks and safety proof.

Someone then raised the central problem of data sharing in freight: how to get shippers, carriers and agencies to share proprietary data. Carson Poe said he would follow up with details about how USDOT's FLOW project approaches industry data. Juan José Erazo observed toll plazas and corridor operators (e.g., Arco Norte) already record useful flows and could feed port planning if integrated. He suggested leveraging those existing operational feeds to improve corridor visibility.

Bertha Martínez pointed out that much data already exists—telematics platforms like Samsara, border and vessel logs, and Cartaporte entries—but systems do not "speak the same language." She argued that the issue is integration and governance rather than data scarcity. Alejandro Ascencio added that Treasury's port-card (bill of lading) dataset contains valuable, non-sensitive fields (vehicle type, origin/destination, tonnage) that IMT has tried to obtain for planning; institutional hurdles and confidentiality concerns remain, but targeted requests for anonymized fields could yield immediate benefits.

Another participant proposed blockchain or tokenized validation so multiple stakeholders can attest to shipment facts. Respondents cautioned that blockchain can help provenance but must not add undue overhead; simpler middleware (Application Programming Interfaces or APIs, schemas) and role-based access controls were recommended as more practical near-term solutions.

On cybersecurity and trust, a speaker recommended two-factor authentication and single sign-on (SSO) to secure access and build confidence among data providers. Others suggested modest commercial incentives, priority slots, reduced dwell fees for carriers that share telematics data.

Finally, the group converged on short, actionable steps:

a. a. Identify a small set of non-sensitive fields to share and request anonymized extracts (Treasury/Cartaporte example)
b. Pilot API integrations with willing carriers or toll operators and deploy basic security (Multi Factor Authentication-MFA/Single Sign On-SSO)
c. Convene a legal-technical working group to draft data-processing agreements, NDAs and access profiles; and
d. Pursuing modest incentives to expand voluntary participation.

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SESSION III ASSESSMENT OF POTENTIAL AREAS FOR ENHANCEMENT, CHALLENGES, AND OBSTACLES

During this session, participants were divided into three groups, each guided by an expert moderator, who compiled and synthesized the insights generated by the team members. The theme for the discussion was: **Technologies and Artificial Intelligence for Traffic Reduction at Intermodal Terminals, Seaports, Airports, and Land Border Crossings.**

The two main questions that were posted to the discussion groups were:

1. Which aspects of traffic reduction can be most effectively enhanced through the application of AI technologies?
2. What are the main challenges to successfully implementing AI-based traffic reduction solutions, and what specific recommendations would you propose to address these challenges?

All groups agreed that AI's highest value is operational: predicting congestion, smoothing peaks through smarter appointment/slot systems, optimizing routing and yard/gate operations, and improving coordination across carriers, terminals, customs and city traffic managers. They prioritized practical, affordable sensing (vehicle Global Positioning System -GPS, inexpensive cameras, IoT combined with computer vision (vehicle/container detection, lane/occupancy measures), predictive analytics/time-series models, optimization (scheduling/assignment), and digital twins for simulation and policy testing.

Group 1 emphasized user-facing interfaces and integration with PCS: smart appointments driven by truck GPS and driver mobile apps, real-time road cameras feeding a command center, and the use of weather/sea-state inputs to anticipate operational impacts. They argued for optional but guaranteed reservation slots and progressive automation of central control while retaining human oversight.

Group 2 focused on data, implementation barriers and institutional arrangements. They stressed essential data types (vehicle flows, cargo status, gate metrics, weather, closed-circuit television - CCTV) and the need for interoperable standards. Main challenges are fragmented, low-quality data; slow regulation and governance; workforce readiness and stakeholder buy-in; and financing/maintenance.

Recommended actions from this group included starting with pilots that demonstrate clear KPIs, building capacity and change management with unions and operators, adopting shared investment or PPP models for infrastructure, and creating governance for secure data sharing. They highlighted successful references from Canada and the People's Republic of China and recommended hybrid approaches that combine carrier GPS, where available, with vision where positioning is missing.

Group 3 gave concrete, domain-specific recommendations across borders, airports and terminals. For border crossings they proposed prior-upload e-manifests, Intelligent Transportation Systems (ITS) on approach roads, routing/segregation by commodity (perishables vs non-perishables), and KPIs focused on processing-time variability rather than absolute time. For airports (El Dorado) they called for a common air-cargo community platform, better submission of truck schedules, and ways to build carrier trust so information is shared. Simulation and research labs were recommended for safe testing; simulated annealing and optimization were cited for assignment problems. They reiterated the technical need for reliable sensors, connectivity, and data for model training, and noted that pilots should be scoped to limited facilities/known carriers.

Across groups the consistent action roadmap was:
a) inventory existing data and pain points,
b) run narrow pilots (single terminal/few carriers) that combine low-cost sensors + carrier GPS + computer vision,
c) define clear KPIs (wait time, throughput, queue length, false positive/negative rates),
d) adopt modular, interoperable platforms with privacy/security-by-design,
e) invest in workforce training and stakeholder engagement, and
f) scale via shared funding models and governance frameworks.

Summarizing the discussion, all groups agreed that it is important to deploy hybrid data strategies (GPS + vision), start small and measurable, prioritize governance and stakeholder incentives, and use predictive AI + optimization + digital twins to move from reactive to proactive, coordinated traffic management.

SESSION IV MECHANISMS FOR COOPERATION BETWEEN THE PUBLIC AND PRIVATE SECTORS: CHALLENGES AND OPPORTUNITIES

The Port of Valparaiso: Collaboration as the Foundation of Its Model, by Mr Juan Marcos Mancilla, Port Authority of Valparaíso, Chile

Institutional Context

Port of Valparaíso (Empresa Portuaria Valparaíso, EPV) is an autonomous state-owned port authority established in January 1998 under Law 19,542 on the modernization of state ports. EPV manages 10 ports from Arica to Punta Arenas under a concession-based scheme (Public–Private Partnership). Under this model, EPV administers and maintains port infrastructure in its role as Port Authority, while the operation of key terminals is concessioned to private operators: Terminal Pacífico Sur (Terminal 1) and Terminal Portuario de Valparaíso (Terminal 2), as well as a third concessionaire, ZEAL Sociedad Concesionaria, responsible for inbound port logistics.

The port's total capacity reaches 11.5 million tons per year and 1.1 million TEUs per year, handling full containers, refrigerated cargo (reefers), break bulk cargo, and cruise operations.

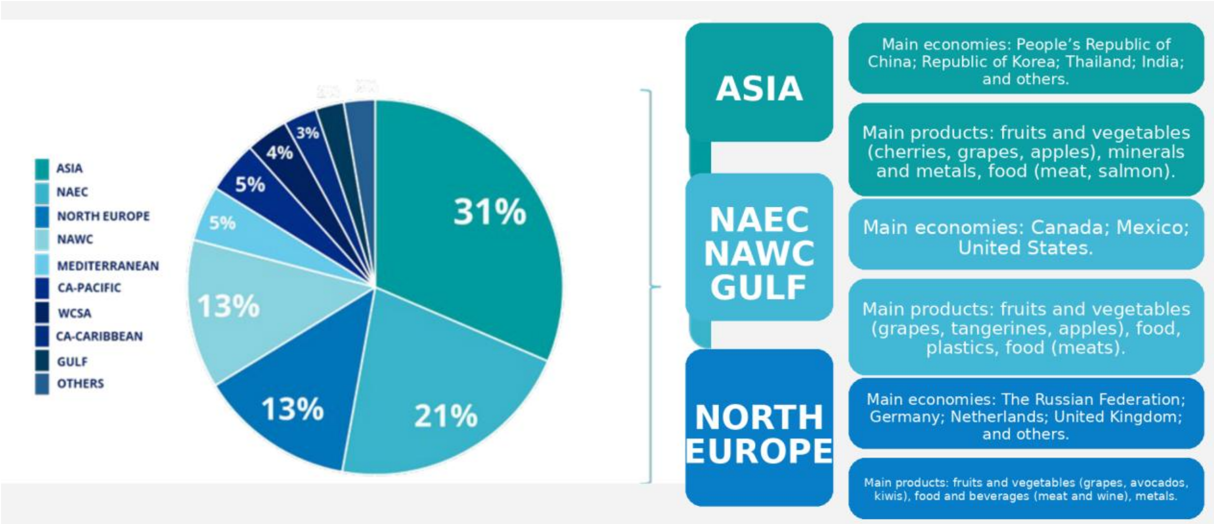
During 2024, the Port of Valparaíso recorded:

- 764,150 TEUs
- 8,432,004 tons
- 35 cruise calls
- 39,000 passengers

This represents 30% of the regional TEU market and 32% of the regional tonnage market.

Port of Valparaíso connects with more than 25 global ports through five regular general cargo services—three to Asia and two to Europe—namely: WS6 (Asia), WSA (Asia), ALX1 (Asia), CLX (Europe), and MSC Europe. In addition, it dominates the regional break bulk market, handling 80% of regional break bulk cargo, and serves as the main cruise homeport in the central zone of the economy.

Graphic 9. Port of Valparaíso Exports 2024



The logistics model enables the transfer of approximately 10 million tons within just 16 hectares, supported by the Logistics Extension and Support Zone (ZEAL), located in the upper part of the city, 11.6 km from the port. ZEAL is the logistics node responsible for coordinating truck entry and exit, validating cargo attributes and traffic flows to prevent congestion at port access points.

In general terms, the main destination for Valparaíso's exports is the United States, accounting for 34% of exports when considering both coasts, followed by Asia with 31%.

Regarding imports, Port of Valparaíso receives the majority of its cargo from the Asian continent, which represents 70% of total imports.

The main challenge for Port of Valparaíso is to lead the cargo transfer market despite limited infrastructure, bringing the best of Chile to different economies and cultures. For this reason, Valparaíso stands out for exports of fruit, wine, and nuts. For example, three out of every four boxes of grapes exported from Chile depart through Valparaíso, and in the case of apples, one out of every two is exported via this port.

Logistics Innovation

Port of Valparaíso has distinguished itself as a pioneer in key initiatives for the port logistics system.

a) Port of Valparaíso Logistics Forum (Foro Logístico de Valparaíso-FOLOVAP)
In response to the need to create a formal entity that brought together the main stakeholders of the port–logistics ecosystem, the idea of forming an organized port community emerged. Established in June 2004, the Port of Valparaíso Logistics Forum has been highly successful, holding monthly meetings with 39 members across more than 209 sessions to date. Key participants include regulatory agencies, shipping agents, off-dock warehouses, shipping lines, port operators, inland cargo transport companies, and universities, among others.

b) Port Logistics System (Sistema Logístico Portuario -SILOGPORT)
SILOGPORT is Chile's first Port Community System. It connects the multiple systems operated by the different organizations that make up the Port Logistics Community of Valparaíso, enabling secure information exchange.

SILOGPORT 3 incorporates a set of services, functionalities, and field devices (barriers, cameras, sensors, etc.), operating as an ecosystem that integrates all logistics-related information.

The major achievement of implementing the third generation of SILOGPORT was the establishment of fully automated access to ZEAL, without human intervention, relying exclusively on predefined business rules.

Graphic 10. The SILOGPORT Structure

What is presented here is a free-flow model for license plate detection and container identification, followed by a "stop-and-go" stage in which the driver's identity is validated through biometric facial recognition mechanisms to ensure the security of the Port of Valparaíso logistics system. Ports are recognized as transfer nodes where organized crime seeks vulnerabilities to carry out illicit activities; therefore, system security is a critical aspect of port logistics.

As shown in the video, the successful identification process takes 28 seconds, whereas under the previous system the average duration was 109 seconds. This improvement has eliminated congestion events at ZEAL entry points, significantly facilitating and streamlining access to the Valparaíso logistics system.

c) Transition to "Industry 4.0"

Port of Valparaíso implemented a technological transition through:

- **Electronic platforms:** Mobile app, online enrollment (integration and transparency).
- **Advanced analytics:** Real-time dashboards, alerts.
- **IoT:** Electronic seals, origin-to-destination traceability, congestion reduction.
- **Artificial Intelligence:** Video analytics, machine learning (driver/cargo validation), automated dispatch.
- **Robotics:** Unattended gates, OCR for license plates and containers.
- **Cybersecurity:** Global standards.

In many successful presentations, mistakes are often overlooked or not discussed. In this case, however, the decision was made to highlight the errors made, allowing the audience to take note, learn from them, and avoid similar issues in future implementations.

- **Implementation errors:**

The initial tender process defined the problem too generically; the importance of another key user—the Transport Coordinator—was not sufficiently emphasized; external consultants did not always have adequate internal business sensitivity; a proper trade-off was not achieved between the port's own business vision and a more "neutral" external perspective; and resistance to change among some operators and users was not fully anticipated.

- **Keys to SILOGPORT's success:**

Efficient and collaborative logistics coordination was achieved; significant reductions in time and congestion were realized; security was enhanced; truck flows increased; and communication with FOLOVAP improved, as the forum was considered part of the system's authorship.

- **Final reflections:**
  - SILOGPORT is a case of digitalization moving from theory to practice.
  - Change management is essential in any technology implementation and process redesign.
  - Public–private collaboration builds trust and acts as a key sponsor for project success.

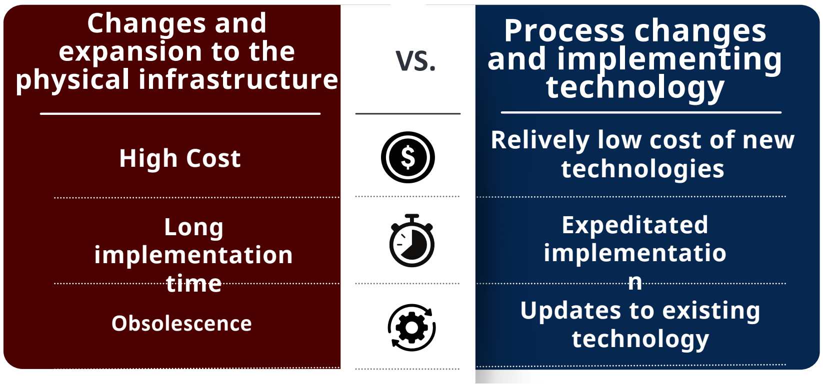
Multiagency Cooperation for the Implementation of Technology at the United States–Mexico Border, by Mr Juan Carlos Villa, Texas A&M Transportation Institute

Juan Carlos Villa drew on more than two decades of border research to frame the United States–Mexico truck trade as a high-volume, highly concentrated system whose performance hinges on multiagency cooperation, pragmatic technology choices, and carefully designed governance. Truck movements across the border have grown from roughly 3.2 million to over 7.6 million annual crossings in recent years, and roughly 73% of bilateral trade moves by truck. Although dozens of crossings exist, a small number of ports of entry account for the bulk of truck flows; that concentration produces acute, localized congestion, large environmental impacts inside urban border corridors, and significant operational fragility when process or IT failures occur.

Villa described the typical operational experience for northbound trucks: a variable sequence of inspections beginning with Mexican customs (random checks), followed by bridge/toll processing, then U.S. federal compound screening (Customs and Border Protection - CBP) where waybills and documents are reviewed and secondary inspection may be triggered, and finally a state vehicle safety inspection. Border crossing delays at any stage can cascade into hours of queuing, long convoys of trucks spilling into adjacent urban streets, higher emissions, elevated logistics costs, increased empty-trip rates, and driver shortages. Southbound flows are usually simpler but equally vulnerable to abrupt stoppages when customs IT systems fail—outages that have produced multi-mile truck queues and major economic cost.

Against the choice of building more physical capacity, Villa argued for prioritizing process redesign and targeted technology investments because they are faster and lower cost, though not without governance challenges. Technologies can deliver measurable improvements in planning and operations, but success requires clarity about ownership, funding, privacy, and sustainability of operations (see following graphic)

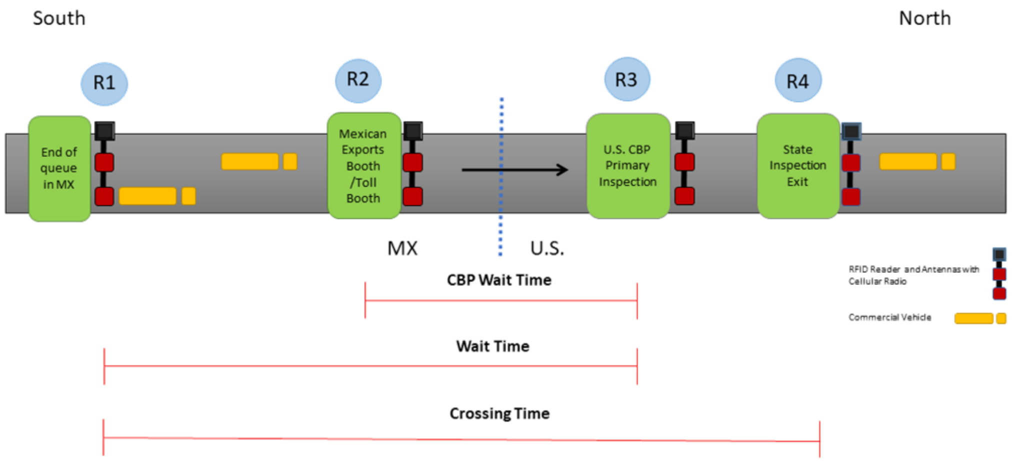
Graphic 11. Potential Solutions at Land Border Crossings.



Villa recounted the evolution of a cross-border wait-time monitoring program: an initial pilot that proved value, a period of handoff and reluctance from some federal agencies, eventual buy-in by U.S. Customs and Border Protection, and a transition to state funding (Texas, California, Arizona, New Mexico) to sustain deployment and analytics. The system's value to transportation master plans is now clear: empirical wait-time metrics allow planners to prioritize bottlenecks and justify investments rather than relying on anecdote.

On sensor and data choices Villa emphasized tradeoffs. The deployed approach used RFID readers and leveraged an existing transponder ecosystem so the system could sample many vehicles without distributing new tags; its design favored anonymized sampling to respect privacy and public planning needs rather than vehicle-level tracking (see following graphic). GPS fleet tracking offers richer, continuous data valuable for private operational optimization, but it introduces commercial and privacy concerns and generally requires opt-in agreements.

Graphic 12. Typical Border Wait Time Measurement System using RFID readers



Villa recommended a pragmatic hybrid posture: public planning systems should rely on anonymized, sampled sensing for regional monitoring while creating opt-in data-sharing agreements and technical pathways for carriers and service providers to contribute higher-resolution GPS data when appropriate and protected.

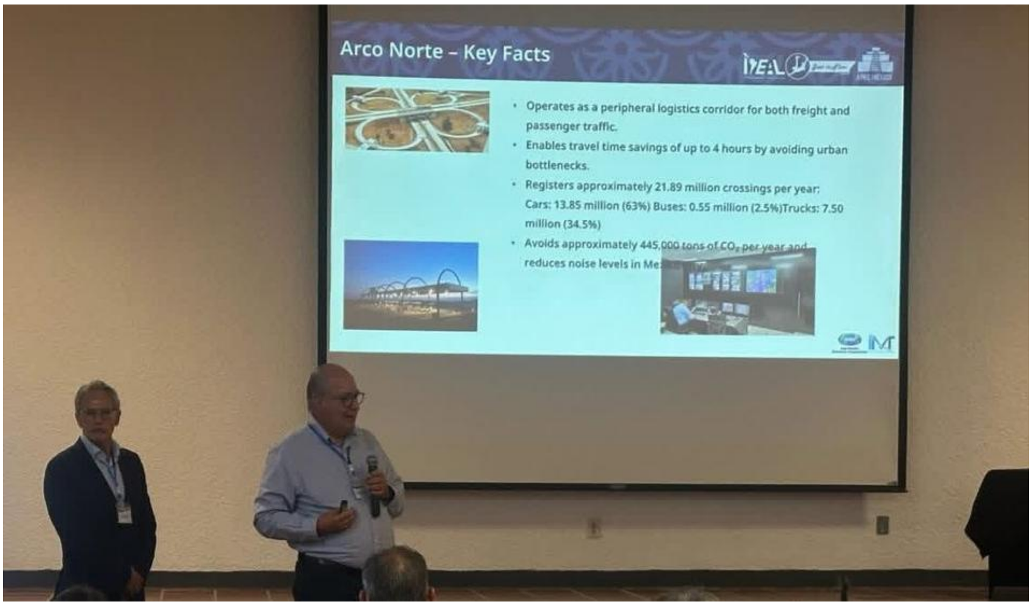
Operational realities present costs and vulnerabilities. Reader installations and cloud analytics are affordable compared with bridge construction but remain subject to theft, vandalism, vehicular damage, and cyber risk; ongoing maintenance and cybersecurity (including annual ethical hacking tests) must be budgeted. Governance and funding matter: pilots must include credible transition pathways to long-term funding and clear assignment of cybersecurity responsibilities. Villa showed how master plans now incorporate wait-time metrics to identify high-return interventions—appointment lanes, pre-clearance expansion, staffing adjustments, and targeted investments in inspection capacity at specific ports of entry.

His recommendations were practical and programmatic. First, pursue interoperable, privacy-preserving public monitoring for planning while enabling voluntary, opt-in data sharing from carriers for operational optimization. Second, build governance and funding plans into pilot designs rather than treating pilots as time-limited research projects. Third, combine sensor networks with process reforms—FAST/FAST-like prescreening, appointment lanes, expanded preclearance—to reduce inspection friction. Fourth, treat cybersecurity and resilience as core requirements from day one and plan for routine ethical-hack testing and rapid recovery. Finally, use measured wait times and anonymized flow data to inform corridor-level strategies that mitigate environmental and congestion impacts in border cities.

Villa's experience underscores a central theme: technology alone is not a panacea. Well-designed, privacy-aware sensing and analytics enable rigorous planning and more surgical infrastructure investment, but they require multiagency governance, sustained funding, careful attention to human and institutional incentives, and an explicit approach to privacy and cybersecurity. When those elements align modest technology investments and process reforms can deliver large reductions in delay, emissions, and logistics costs, and can make border crossings more predictable for carriers and communities alike.

SESSION V IMPORTANCE OF DIGITALIZATION IN THE TRANSPORTATION SECTOR

AI-Powered Smart Corridor: Present Innovations and Future Horizons for the North Bypass Tollway of Greater Mexico City, by Mr Juan José Erazo, Just in Flow, S.A. de C.V. and Mr Miguel Barousse, IDEAL, S.A. de C.V.



The Arco Norte (Northern Bypass Toll Road) project reframes highway operation by shifting attention from toll-plaza mechanics to continuous route-level management: a staffed, sectioned operational model supported by pervasive sensing, edge/GPU computing, and AI. IDEAL and Just In Flow presented a pragmatic program that converts an existing ITS backbone into an AI-augmented, operations-driven corridor capable of real-time detection, predictive maintenance, dynamic safety management, and logistics facilitation for one of Mexico's busiest freight arteries.

Context and objectives Arco Norte is a 223-km closed toll ring around Greater Mexico City that already carries significant freight and is rapidly surrounded by logistics parks and distribution centers. The corridor's combination of very high truck intensity, concentrated freight flows and proximity to urban areas makes it a strategic testing ground for smart-corridor technologies. The program's central objective is to reduce safety risks, eliminate recurring operational peaks, improve asset availability and deliver measurable benefits to freight throughput and urban externalities by turning routine digital signals into timely, actionable information.

Operational model and organizational change Rather than only increasing roadside sensors, Arco Norte's approach reorganizes operations into sectional teams backed by a single, intelligence-rich control center. Each road segment has dedicated patrols, first-response and maintenance crews tied into a staffed command structure similar to toll-plaza operations. The control center moves from passive monitoring of camera feeds to active incident orchestration informed by automated alarms and analytics. This human+AI configuration is designed to ensure rapid, coordinated responses to stoppages, debris, vandalism, pavement defects, perimeter breaches or suspicious activity that may signal criminal threats.

Technology architecture and deployments. The technical strategy layers three elements: edge/vehicle computing, corridor sensing, and centralized GPU analytics with a digital-twin simulation core.

- Edge and mobile sensing: Inspection and patrol vehicles are equipped with onboard GPU processors, laser profiler meters and multi-camera arrays running trained neural networks to detect pavement distresses, measure roughness and friction indices, detect sign damage or missing reflectivity, and flag objects on the carriageway. These "roving sensors" convert routine patrols into continuous surface inspection data at scale, enabling much higher temporal frequency than periodic specialist surveys.

- Fixed corridor sensors and ITS integration: Existing ITS cameras, radars and environmental sensors are augmented with AI vision algorithms to classify vehicle types, estimate speeds and accelerations, and detect anomalies (stopped vehicles, dropped loads, fencing breaches). Routine digital signals (radar, video, loop counters) are transformed into richer operational metrics—vehicle class heatmaps, convoy formation alerts, micro-peak forecasts—that feed real-time operations.
- Centralized analytics, digital twin and scenario simulation: All streams are consolidated into a GPU-backed control center and a digital twin that supports dynamic traffic simulation, predictive maintenance scheduling, risk mapping and "what-if" scenario testing (e.g., bridge failure, slope runoff, mass convoy arrivals). The twin permits preemptive resource allocation, virtual drills, and ROI testing for investments before committing capital.

Graphic 13. Conceptual Arco Norte AI-powered Traffic Management Center.

Applications and early results. The project prioritizes high-impact, low-marginal-cost uses where AI enables routine tasks previously infeasible:

- Continuous pavement monitoring: AI detects defects, classifies failure modes and computes IRI/friction proxies during everyday patrols, turning frequent runs into predictive maintenance inputs that reduce emergency repairs and extend asset life.

Graphic 14. J-FLOW Edge computing AI pavement monitoring system.

- Automated incident and object detection: Real-time alarms for stopped vehicles, debris, fallen signage or sudden changes in roadside conditions allow immediate dispatch of section teams, reducing dwell time and secondary incidents.
- Dynamic signage and traveler info: Accurate, timely classification of incidents enables tailored traveler advisories and adaptive speed limits to manage safety and flow.
- Security and perimeter monitoring: AI flags fence breaches, unusual roadside objects or patterns consistent with illegal activity; the system supports faster security response and safer rest areas for drivers.
- Logistics and booth area optimization: Vision algorithms convert camera feeds into logistical metrics at toll plazas and choke points (vehicle classification, queue lengths), enabling dynamic booth allocation and improved throughput without hardware expansion.

Graphic 15. J-FLOW AI-based roadway analytics and monitoring outputs.

Human factors and governance. The team emphasized behavioral and institutional work alongside tech deployment. Drivers and patrol crews require usable interfaces (alerts routed to dispatch), training to integrate AI outputs into decisions, and clear SOPs for false-positive management. Financing and governance are crucial: concessionaires must align private investment incentives with public safety goals, and road agencies or institutes (e.g., IMT) should codify standards so projects scale and knowledge are shared domestically.

Phased roadmap and capability maturation The project defines staged deliverables: initial AI "basic" models that apply established pattern-recognition to routine tasks; an intermediate layer where AI assists human analysts in pattern discovery and anomaly interpretation; and a mature stage where complex behavioral modeling and cooperative systems (vehicle-to-infrastructure) support proactive interventions. This progression balances early wins (pavement detection, object alerts) with longer-term research (driver behavior modeling, cooperative ITS).

Challenges and considerations Key constraints include financing for GPU/edge deployments, data management and privacy, maintenance of distributed hardware, and organizational capacity to act on alarms reliably. The flood of new data raises governance questions—who owns and uses the dataset, how long is it retained, and how are false alarms handled operationally. The presenters argued for institutional leadership (IMT) to define priorities and financing models so private concessionaires can invest without bearing unsustainable risk.

Why this matters for logistics corridors Arco Norte demonstrates a model for freight corridors where modest technology and organizational redesign leverage existing infrastructure to deliver outsized safety and throughput gains. By moving from visual monitoring to intelligence-driven operations, concessionaires can reduce unplanned delays, lower maintenance costs, and improve predictability for shippers—yielding measurable competitiveness and social benefits in urbanized logistics corridors.

Closing Arco Norte makes a compelling case that smart corridors are not solely about adding sensors but about reorganizing operations, deploying targeted AI where it displaces costly manual work, and embedding governance and finance from project inception. The initiative is a replicable template for freight corridors in dense metropolitan regions: combine mobile inspection fleets, edge computing, AI vision and digital twins to convert abundant digital signals into safer, more predictable, and more efficient logistics flows.

Harnessing Real-Time Signals for Predictive Transportation Management, by Ms. Asha Sharma, Independent Consultant

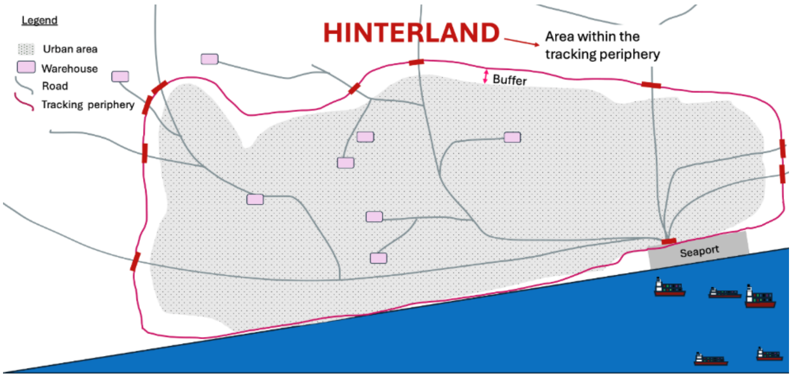
Ms. Sharma's presentation addressed a persistent logistics problem, unmanaged fluctuations of seaport trucking volume in the Hinterland, and proposes a practical, deployable system to convert real-time detections into actionable route-level traffic management. The premise is simple: existing port gate systems and isolated travel-time feeds do not provide the structured, system-wide view needed to manage how truck flows interact with urban road networks. Without that view, Hinterland roads remain reactive and brittle: peaks form, convoys and spikes stress intersections and arterials, emissions rise, and supply-chain predictability suffers.

The problem statement is focused , operational: Hinterland presently there is no system for trucking flow management between the seaport and the Hinterland. The proposed solution identifies that what is required is tracking a truck, anticipating its route and making volume projections to assist traffic flow management on these routes, and scaling this up for all trucking traffic.

For the purpose of this solution, the origin is defined as the point where truck enters the tracking system, and destination is defined as where the track exits the tracking system. Note that the seaport is not a part of the Hinterland for this solution. The tracking begins at or before entering a defined area and ends at or after exiting it. The tracking area is defined next.

Toward this solution a new definition of Hinterland is created. As seen in figure 1, Hinterland in this context will be a parcel containing the urban development being served by the seaport, and whose boundary is at a buffer to edge of urban development. The tracking equipment is deployed on the periphery on designated trucking routes, and on roadways that are deemed relevant to trucking traffic. While Hinterland parcel itself is expandable, a well determined buffer to the prevailing urban developments will both accommodate foreseeable infrastructure growth and minimize moving of tracking equipment installed at the periphery of the existing buffer.

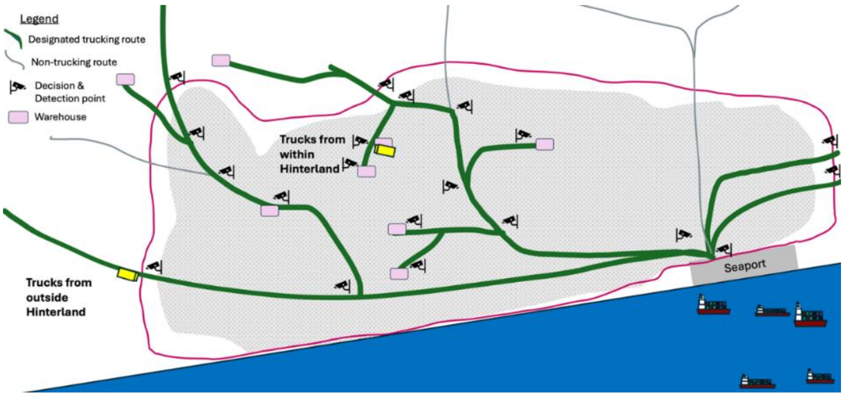
Graphic 16. Defining Hinterland – the area of coverage of the solution



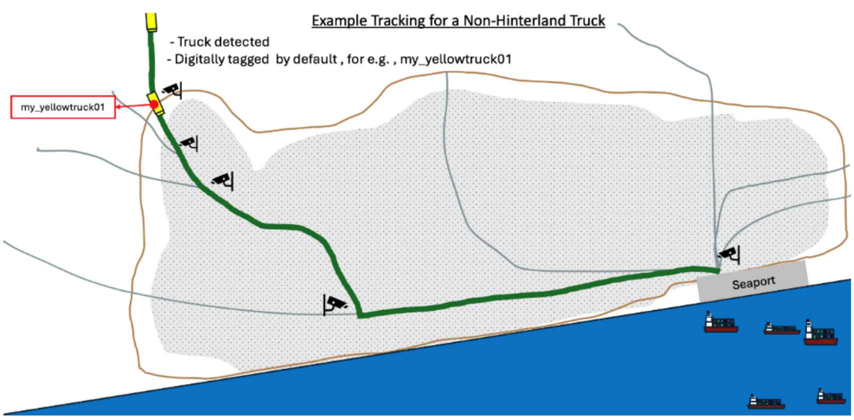
It then builds a lightweight yet robust data model around a single persistent tracking variable: a digitally tagged presence. As the seaport is outside the Hinterland perimeter by definition the system does not track inside the port

The tracking is within the Hinterland only. This means that once a truck exits the Hinterland, it is no longer tracked, and the digital tag is closed by the system. If and when it enters the system again, a new digital tag is assigned to it.

Graphic 17. Sample layout of equipment at detection and decision points



Graphic 18. Example tracking of a truck originating outside the Hinterland..



Note: the route ending at seaport where it exits the systems as it entered the seaport and is not tracked

The system creates its own observability by instrumenting the periphery and decision points with detection sensors Trucks entering the perimeter receive a transient digital tag (anonymized token) and thereafter are tracked by the detection network as they progress through Hinterland, as defined for this solution. Where trucks originate inside the perimeter, the system similarly tags them at their entry point. The stream of inferred movement decisions yields route inferences that would be adequate for estimating volumes per route and for short-term flow forecasting
.

The concept of operations emphasizes progressive, supervised deployment. The solution is positioned as “applied intelligence”: AI that has been conceptualized, designed and created from algorithmic logic pertinent to the Hinterland under question, and trained models rather than an opaque, or off-the-shelf, or borrowed software.

In addition to letting the organization identify what matters to them to them, defining key performance indicators (KPIs) tied to operational goals, an acceptable margin of error must be identified. This metric would allow the organization to create, observe and evaluate, while still in the testing phase, the circumstances that lead to a system experiencing a breakdown, and consequently determine the performance envelope of the system, and its operational impact: e.g., if 10% of tags are missed or dropped mid-tracking, what does that translate to on-ground impact, and how quickly can source of such an error be identified.

The recommended rollout is iterative: deploy the system, including any dependent and support systems, and run the system passively first i.e. observing without acting, comparing AI inferences and projections with operator knowledge of the system, refining models and logic. introducing automated measures for traffic management

For highest success of the system, subject matter experts, and veteran operators for their experience are essential for developing the most complete software. Their knowledge and experience would be instrumental in capturing edge cases and anomalies experienced over their career, into the decision logic; their tacit knowledge is translated into the AI’s layered rules and framework
Key engineering principles anchor the design:

- Minimal necessary data: favor the least data required to deliver reliable outputs (Occam’s razor). The approach reduces dependency on proprietary feeds and adverse privacy/legal negotiations.
- Modular architecture: independent functional blocks (detection, route inference, forecasting, operator UI) with limited interfaces to ease maintainability and progressive upgrades.
- Fault tolerance: explicitly train and test models for complete, partial, and missing data scenarios. Define an explicit error budget and evaluate system performance under realistic detection loss (e.g., X% of tags missed) so operators can understand expected uncertainty.
- Human-AI collaboration: AI handles routine pattern recognition and volume forecasting, while humans will continue to supervise the system, managing new anomalies.
- Privacy and non-intrusiveness avoid storing personally identifiable information or continuous tracking outside the system boundary; uses ephemeral tokens for planning and control.

Because trucks move at urban speeds, i.e. not fast, the system will have sufficient lead time to recommend management measures such as dynamic signage, preemptive lane allocation at toll plazas, temporary turn restrictions, or staggered appointment windows to smooth peaks.

Analytics useful to traffic managers and port communities: per-route volume estimates, short-horizon congestion forecasts, predicted convoy formations, and decision-point turning probabilities that enable proactive signal timing adjustments, dynamic routing advisories, and targeted dispatch of enforcement or incident response assets.

Deploying the system requires attention to sensors, computing, and governance. Sensor types include detection cameras preferably compatible with A.I. systems, supplemented where needed by other relevant technologies Governance requires pre-defined objectives for use documented decision logs for traceability, and stakeholder agreements to define acceptable error margins and escalation protocols. A pragmatic deployment path includes the following steps:

1. Pilot passive observation on a test corridor to test detection accuracy, stability of the system in maintaining the tag on the identified truck during its entire stay in the system, and route inference logic.
2. Run a supervised period where operators compare AI inferences to real operations and refine rules for anomalies and edge cases.
3. Introduce advisory outputs (recommended signal timing adjustments) and quantify benefits
4. Scale this to create the system for the Hinterland.

Cybersecurity, data retention policy, and privacy compliance, at least in the macro sense must be identified and potentially codified. This may be completed in stages with simplest measures at the start of the project and adding more sophisticated measures later on.

The method balances technical feasibility and political practicality. It avoids protracted data-sharing negotiations by creating its own anonymized observability, yet can hand-off the data into another system, should a stakeholder be interested. It positions human experts as central to model reliability, thereby building institutional trust and avoiding unrealistic automation expectations. Because it focuses on the Hinterland perimeter rather than seaport interior, it aligns with municipal and DOT jurisdictions and delivers visible public benefits (less spillback congestion, lower emissions, safer arterial operations).

This pragmatic, detection and tracking -based perimeter approach yields a deployable predictive management capability without heavy dependence on proprietary carrier feeds. By instrumenting the decision points, modeling route choice, and coupling AI forecasts to human supervision and phased interventions, agencies can move from reactive congestion response to anticipatory management, reducing peak impacts on city's roadway network improving drive time reliability for communities. Most importantly, unlike traditional methods which rely on peak period traffic management solutions, this solution can accommodate fluctuations in the tracking traffic in the Hinterland, arising from Seaport related activities, through the day, which was the original problem statement to be solved.

Attendees' Survey 1

In this activity, participants received a link to complete a survey that collected their insights on the importance of digitalization in the transportation sector and traffic management. The Survey 1 questions are presented in Appendix V and the Survey 2 in Appendix VI. The survey's objective was to identify both opportunities for improvement and potential challenges in these areas. The summary of surveys' response is presented below.

International, Institutional Participation and Expert Profiles
The survey included the participation of experts from multiple economies, including Chile; Colombia; India; Mexico; Thailand; Panama; and the United States, which provided an international and multidisciplinary perspective to the analysis of the results.

Participants represent a diverse range of academic, governmental, port, airport, and private-sector institutions, including CETYS Universidad / AML, the Port Authority of Thailand, the United States Department of Transportation (USDOT), Empresa Portuaria Valparaíso, Kale Info Solutions, UNAM–FI–LAPI, Just in Flow Ecosystems, El Dorado Airport – OPAIN, IDEAL, independent consultants, and the Georgia Tech Panama Logistics Innovation and Research Center.

In addition, the professional backgrounds of the experts encompass strategic, technical, and decision-making roles, such as International Logistics Coordinators, port research and development (R&D) officers, IT strategic planning specialists, government officials, chief logistics officers, technology and (ITS professionals, Information Technology – IT, IoT, and artificial intelligence consultants, airport concessionaires, highway operations sub-directors, engineering consultants for airport and roadway traffic systems, as well as research center directors.

The combination of geographic, institutional, and professional diversity strengthened the technical robustness, practical relevance, and regional applicability of the survey results, ensuring that the conclusions reflect both the strategic perspective and the operational experience of key stakeholders in the transport, mobility, and logistics sectors.

Digitalization of the Transport Sector Today
Experts agree that digitalization in the transport sector has evolved beyond being merely a technological tool to become a strategic driver of efficiency, facilitation, and competitiveness. According to the responses, digitalization is essential to understand and manage the current complexity of goods and vehicle flows, particularly given the high volume of operations that characterize modern transport and logistics systems.

A central element identified by experts is the critical role of data. Digitalization enables dynamic data collection, real-route visualization, analysis of freight and truck flows, and the precise identification of bottlenecks and congestion issues. Without reliable data and digital tools, experts note that it becomes virtually impossible to make informed decisions at scale, plan adequate infrastructure, or define strategic nodes, such as truck parking areas in port environments.

Responses also highlight that digitalization enables process optimization, improves operational efficiency and information accuracy, and reduces data reprocessing and error margins. These benefits translate into higher service levels, lower operating costs, and improvements in quality of life, both for operators and for society as a whole.

Experts further emphasize that digitalization contributes simultaneously to security, trade facilitation, and sustainability, by enabling the development of predictive models, prevention strategies, and more efficient resource management, including the reduction of greenhouse gas emissions.

Finally, digitalization is recognized as a current and tangible necessity, driven by the availability of advanced technologies, applications, and tools, as well as by the demands of the global economy. In this context, experts stress that adopting digital solutions not only strengthens planning and decision-making by authorities but is also essential to maintain competitiveness in response to the expectations of international clients and markets.

Main Sources of Congestion in the Transport Sector

Expert responses indicate that congestion in the transport sector has a multifactorial origin, closely linked to the interaction between infrastructure, operations, data governance, and demand behavior. While specific sources vary across economies, there is a high degree of convergence regarding the structural patterns that generate congestion.

Experts consistently identify seaports as one of the primary generators of congestion, particularly when they are located in urban areas or have limited connectivity. The lack of synchronization among terminals, port authorities, transport operators, manufacturers, and warehouses leads to unplanned truck arrivals, access saturation, and bottlenecks within yards and adjacent road networks. This situation is further exacerbated by insufficient infrastructure readiness and by shortcomings in communication and information exchange among the stakeholders involved.

Another critical source of congestion highlighted by experts is found on highways and road corridors, where high traffic volumes, resulting from the coexistence of freight and non-freight flows, exceed available capacity. In several economies, experts also point to issues related to infrastructure conditions, disruptions caused by accidents or vehicle breakdowns, as well as delays at toll plazas and control points, including law enforcement interventions.

Border crossings, customs facilities, and ports of entry also emerge as significant congestion hotspots. Experts emphasize that low levels of digitalization, duplicated procedures, and lack of system integration generate substantial delays, negatively affecting both trade facilitation and security.

In the airport environment, particularly in economies with a high share of perishable cargo, congestion is attributed to market behavior and the concentration of cargo generators, which place pressure on infrastructure and operational processes within very narrow time windows.

Finally, experts agree that many of these congestion sources are closely associated with the lack of integrated, timely, and shared data. The absence of digital tools that enable flow visualization, demand peak anticipation, and stakeholder coordination limits the ability of authorities and operators to plan infrastructure, optimize operations, and prevent bottlenecks especially in urban contexts where daily mobility and logistics activities converge.

Most Transformative Technological Tools in the Transport Sector

Expert responses show a high level of consensus in identifying IoT as the most transformative technological tool in the current transport and logistics context. Repeatedly, participants point out that IoT serves as the foundational enabler of digitalization, as it allows the continuous and real-time capture of data from vehicles, infrastructure, logistics assets, and operational environments.

Alongside IoT, experts highlight telematics as a key component for the collection, transmission, and monitoring of operational information, particularly across fleets, logistics chains, and multimodal transport systems. In this regard, it is recognized that both IoT and telematics enable the generation of large volumes of data, which can subsequently be analyzed and leveraged through more advanced technologies.

AI and Big Data are identified as tools with high transformative impact, especially in later stages of the digitalization process. Experts agree that these technologies make it possible to analyze large datasets, develop predictive models, optimize processes, and support informed decision-making. However, it is emphasized that their effectiveness depends directly on the quality, availability, and continuity of data, which are primarily provided by IoT and telematics systems.

In addition, some responses highlight the importance of specialized expertise, thoughtful use of technology, and programming and development capabilities as cross-cutting elements that enhance the impact of digital tools. From this perspective, transformation does not rely solely on technological adoption, but on its strategic integration with technical and operational knowledge.

Overall, experts consider that all these tools are complementary, emphasizing that IoT and telematics act as fundamental enablers, while Big Data and artificial intelligence represent advanced layers of analysis and optimization, together forming an integrated technological ecosystem for the transformation of the transport sector.

Experience in the Implementation of Digital Solutions in Transport Operations

Expert responses indicate that the implementation of digital solutions in transport operations is at a heterogeneous stage, combining successful cases, pilot experiences, and persistent structural challenges, depending on the institutional, sectoral, and geographic context.

Several experts report active, hands-on experience in the design and implementation of digital solutions, both from an academic perspective and through direct collaboration with industry. These experiences include the adoption of transport management systems (TMS), route optimization tools, IoT-based visibility systems, analytics dashboards for demand forecasting and capacity planning, as well as the development of specialized software for freight forwarders. In these cases, reported benefits include improved service reliability, reduced empty kilometers, strengthened cross-border coordination, and enhanced data-driven decision making.

In port and airport environments, experts report the implementation of (PCS, Truck Slot Management systems, and airport community platforms, with positive results aimed at increasing throughput, reducing waiting times, and improving coordination among logistics stakeholders. Additionally, applications of artificial intelligence to optimize operations and maintenance activities are also mentioned.

In the road sector, experiences include the implementation of ITS, electronic toll collection, and the design of advanced operational models, indicating a gradual shift toward more digital approaches in road infrastructure management.

However, several experts emphasize that digitalization still faces significant barriers. In some contexts, particularly in emerging economies, implementation remains complex and limited, with progress often concentrated in isolated or small-scale projects used as proof-of-concept initiatives. Resistance to change is identified as one of the main obstacles: in large companies, it is related to data protection and data governance concerns; in smaller companies, to the technology adoption gap; and in the public sector, to the lack of continuity in programs and policies.

Finally, experts agree that the fragmentation of actors involved in transport systems hinders large-scale digital implementation, reinforcing the need for clear use cases, phased adoption strategies, and interinstitutional coordination mechanisms to consolidate the digital transformation of the sector.

Impact of Digitalization on Decision-Making for Logistics Planning

Expert responses indicate that digitalization has had a predominantly positive and transformative impact on decision-making related to logistics planning, by providing greater operational visibility, access to real-time information, and enhanced analytical capabilities. In contexts where it has been implemented, digitalization has enabled improvements in both the accuracy and speed of key decisions, such as route planning, inventory management, cross-border operations coordination, and resource allocation.

Experts emphasize that digitalization is inseparable from the decision-making process, as it enables the use of data to shift from reactive approaches to predictive frameworks, supporting incident prevention, bottleneck reduction, and improved performance of logistics processes. Concrete benefits are reported in terms of reduced operational times, enhanced security in port areas, smoother movement of passengers and cargo, and greater efficiency in traffic management, including applications such as predictive maintenance, inspection and monitoring systems, and ITS solutions.

Responses also indicate that digitalization has contributed to the reduction of manual and paper-based processes, particularly within large government agencies and key trade and transport entities. In sectors such as airports and metropolitan areas, the use of dashboards and digital tools has improved monitoring capabilities and analytical capacity for both strategic and operational decision-making.

However, experts also stress that the impact of digitalization is not homogeneous. In some economies and sectors, digitalization remains incipient or non-existent, with uneven progress across highways, customs, railways, airports, seaports, and transfer stations. The lack of advanced technological capabilities, particularly within the public sector and in agencies where logistics is not a priority, limits the full realization of digitalization benefits and results in the continued reliance on manual processes that affect efficiency and interinstitutional coordination.

Overall, experts agree that although digitalization in the transport and logistics sector is still in a maturation phase, the progress achieved to date has delivered clear positive results, and its consolidation is essential to reduce logistics costs, improve system performance, and strengthen the sustainability and security of operations.

Level of Digitalization in Participating Economies

Expert responses indicate that the level of digitalization in their respective economies is predominantly at an intermediate stage, with a clear concentration in the "emerging" and "moderately advanced" categories. This distribution reflects that, while there have been significant advances in the adoption of digital technologies in the transport and logistics sector, the transformation has not yet been fully consolidated or harmonized.

A substantial share of experts consider that digitalization is at an emerging stage, characterized by the implementation of pilot projects, partial solutions, and uneven progress across sectors and stakeholders.

At this level, technological adoption typically depends on specific initiatives, isolated institutional capabilities, and the leadership of certain public or private actors.

On the other hand, several experts identify their economies as moderately advanced, suggesting the existence of operational digital systems, analytics applications, management platforms, and decision-support tools that are already delivering tangible benefits in efficiency, security, and planning.

Nevertheless, even in these cases, experts acknowledge that gaps remain in interoperability, data integration, and scalability.

Finally, a minority of responses indicate that digitalization in the transport sector is still non-existent or very limited, highlighting regional heterogeneity and the need to strengthen capabilities, digital infrastructure, and institutional frameworks in order to close these gaps.

Overall, expert perceptions confirm that participating economies are undergoing a digital transition process, with meaningful progress but also with structural challenges that must be addressed to achieve a more integrated, sustainable, and future-oriented digitalization, aligned with the evolving demands of modern trade and mobility.

Tools and Technologies Used to Monitor and Manage Freight Traffic
Expert responses indicate that participating economies employ a diverse combination of digital technologies to monitor and manage freight traffic, with varying levels of maturity and adoption. Overall, positioning and sensing technologies are observed to constitute the most widespread foundation of current systems.

The use of GPS and sensors is identified as a widely adopted practice, particularly in organized road freight transport, where a large share of fleets is already equipped with real-time tracking systems. These technologies enable the monitoring of vehicle location, travel times, schedule compliance, and operating conditions, providing basic yet essential visibility for freight traffic management.

In addition, experts mention the use of video analytics through cameras, ITS, and highway control centers, as well as license plate recognition technologies and, in some cases, facial recognition, which support vehicle flow monitoring, operational control, and security.

In several economies, these tools are integrated into digital traffic management platforms and electronic tolling systems.

Experts also report the use of RFID, TAGs, and identification systems, mainly for truck monitoring, controlled access, and operations in port and logistics environments. These technologies are described as having a medium level of maturity, with plans for strengthening and expansion in the short term.

At a more advanced level, some economies and stakeholders have begun to incorporate artificial intelligence, predictive models, machine learning, digital twins, and forecasting tools, as well as digital freight platforms and electronic customs systems. However, experts agree that these technologies are still largely in pilot, research, or limited-adoption phases, and that the primary challenge lies not in data collection, but in effectively leveraging data for advanced analytics and decision-making applications.

Finally, it is recognized that while multiple operational tools exist to monitor and manage freight traffic, in many cases the data generated are not fully integrated or exploited, limiting the potential for more sophisticated solutions focused on optimization, prediction, and proactive congestion management.

Level of Readiness for the Integration of AI-Driven Tools
Expert responses indicate that the level of readiness to integrate artificial intelligence-based tools is predominantly at an intermediate stage, with a clear concentration in the categories “preparing but lacking resources” and “partially prepared.” This distribution reflects that, while there is a clear awareness of AI’s potential and an institutional willingness to adopt it, structural limitations persist that hinder large-scale implementation.

Most Difficult Data to Collect, Integrate, or Share in the Transport and Logistics Sector
Expert responses indicate that the greatest data management challenges in the transport and logistics sector are concentrated in information that requires real-time integration, interinstitutional coordination, and cooperation among multiple public and private stakeholders.

Experts consistently identify queue prediction at terminals and ports as one of the most difficult datasets to manage. This challenge is associated with operational variability, unsynchronized truck arrivals, dependence on multiple processes (terminals, authorities, transport operators, customs), and the lack of integrated real-time data needed to anticipate demand peaks and congestion.

Another significant challenge highlighted is real-time traffic monitoring, particularly in complex road networks and in urban and logistics environments where different types of users converge. Obtaining reliable and continuous data requires extensive technological infrastructure, system interoperability, and advanced analytical capabilities.

Experts also emphasize difficulties related to customs information, especially regarding data exchange between public and private entities, as well as among different government agencies. Institutional, regulatory, and technical barriers limit the fluidity of information exchange and negatively affect supply chain visibility.

Incident and risk management is likewise identified as a complex data domain, due to the unpredictable nature of events, the need for timely information, and the coordination required among multiple actors for detection, response, and mitigation.

Finally, experts note that vehicle flow optimization and the prediction of cross-border disruptions, such as those affecting rail transport, present additional challenges, as they require reliable historical data, real-time information, and analytical models capable of capturing cascading impacts across transport networks.

Overall, expert perception underscores that the most difficult data to manage are those that transcend organizational boundaries, depend on multi-actor collaboration, and require advanced capabilities in data integration, analytics, and governance to generate operational and strategic value.

Main Challenges for Digital Adoption in the Transport Sector

Expert responses show a clear consensus that the main challenges for digital adoption in the transport sector are not exclusively technological, but are instead deeply linked to cultural, institutional, and financial factors.

Predominantly, experts identify cultural resistance to change as the most significant obstacle. This resistance manifests in both public and private organizations and is associated with operational inertia, a preference for traditional processes, lack of trust in new technologies, and limited user ownership of digital tools. In several cases, experts note that there is even a lack of recognition of the need for improvement, which slows digital transformation processes from their very early stages.

Institutional constraints are also highlighted, particularly within the public sector. Some responses indicate that public management does not always prioritize or actively promote digitalization, resulting in lack of leadership, discontinuity of programs, and weak interinstitutional coordination. This situation hinders the adoption of digital solutions at a system-wide scale.

Regulatory frameworks are likewise identified as a relevant challenge. The absence of clear, up-to-date, and digitally aligned regulations limits interoperability, data sharing, and the adoption of emerging technologies in the transport and logistics sector.

From a financial perspective, experts point out that resource availability represents a significant barrier, particularly when new digital infrastructure or high upfront investments are required. These financial constraints often intersect with cultural challenges, especially regarding the effective adoption and appropriation of technologies.

Overall, expert perception highlights that digital adoption in the transport sector requires comprehensive and integrated strategies that simultaneously address cultural change, institutional strengthening, regulatory adaptation, and financing, in order to achieve a sustainable and long-term digital transformation.

The Role of Regulation and Public Policy in the Digital Transformation of the Transport Sector

Expert responses agree that regulation and public policy play a dual and decisive role in the digital transformation of the transport and logistics sector. On the one hand, when clear, updated, and coherent regulatory frameworks are in place, public policies can significantly accelerate the adoption of digital solutions; on the other hand, when regulations are outdated, inconsistent, or slow to evolve, they tend to constrain the pace of technological transformation.

Experts emphasize that public policies are highly important and potentially central to digitalization, particularly with regard to the definition of standards, modernization of procedures, and establishment of common rules. Examples of regulatory-enabled progress include electronic invoicing, digital customs systems, and traceability requirements, which have contributed to the modernization of specific processes in some economies.

However, a recurring concern is that the speed of regulatory updates is often much slower than the pace of technological change, creating misalignments between available technical capabilities and existing regulatory frameworks. Several experts consider that regulation, in its current state, does not move fast enough to respond to the demands of more efficient, digital, and integrated supply chains.

Significant gaps in institutional coordination and interoperability are also identified, particularly in relation to data exchange among government agencies and between the public and private sectors. While some public policies support research and education, other areas of public administration limit information sharing and joint decision-making, thereby reducing the overall impact of digital initiatives.

In certain contexts, experts perceive a tendency toward overregulation, which introduces additional complexity and discourages innovation. In contrast, some economies are recognized for having more progressive digitalization policies, although concrete implementation at the firm level may remain less visible due to confidentiality considerations.

Finally, experts highlight the need to advance toward common public policies for digitalization, particularly in citizen- and user-facing transport processes, as a starting point for systematic data generation. Likewise, they stress the urgency of establishing clear data-sharing protocols, avoiding duplication across institutions and promoting more efficient data governance.

Overall, expert perception confirms that regulation and public policy can act either as key enablers or as significant barriers to the digital transformation of the transport sector, and that their effectiveness will depend on continuous updating, institutional coherence, and alignment with technological evolution.

Dominant Trends in Transport Digitalization over the Next 5–10 Years

Expert responses show a high level of convergence in the view that transport digitalization over the next five to ten years will be driven by the integration of advanced data, automation, and connectivity technologies, rather than by isolated solutions.

Experts consistently identify artificial intelligence and data-driven approaches (Big Data and data-driven platforms) as central pillars of transformation, particularly for advanced planning, operational optimization, and decision-support. AI is primarily viewed as an enabling tool, capable of enhancing the understanding of transport systems, anticipating issues, and proposing more efficient alternatives for the movement of freight and people.

IoT emerges as a fundamental component for continuous real-time data capture, enabling visibility of assets such as trucks, port equipment, and even people. Combined with computer vision and video analytics, IoT will support a wide range of operational needs through intelligent monitoring and supervision of infrastructure and transport flows.

Another recurring trend is the use of digital twins, which, supported by IoT and advanced analytics, will enable the simulation, evaluation, and optimization of transport systems prior to physical interventions, improving planning processes and reducing operational risks.

Experts also highlight the relevance of community digital platforms, such as PCS, as well as digital trade documentation, which will contribute to improved coordination among stakeholders and enhanced efficiency at key logistics nodes.

In addition, standardization and interoperability are identified as critical trends. Beyond digitalization itself, experts emphasize that harmonization in how data are collected, shared, and used will be decisive in maximizing the impact of digital technologies, avoiding fragmented solutions and facilitating system integration.

Finally, some responses underscore that alongside these technologies, sustainability-oriented approaches will gain greater importance, including smart routing, emissions tracking, and more efficient asset utilization, supported by digital platforms and advanced analytics.

Overall, expert perspectives suggest that the future of transport digitalization will be defined by integrated technological ecosystems, in which AI, IoT, digital twins, advanced analytics, and interoperability work jointly to enhance the efficiency, resilience, and sustainability of transport systems.

A "Fully Digitalized" Transport System

According to participating experts, a fully digitalized transport system is one in which all ecosystem actors, carriers, shippers, ports, terminals, customs, authorities, and regulators operate in an integrated manner through interoperable platforms, using reliable real-time data, automated processes, and fully digital documentation.

In such a system, decision-making is predominantly predictive rather than reactive, supported by real-time analytics, forecasting models, and advanced decision-support tools. Information flows continuously and transparently across the entire supply chain, providing end-to-end visibility and eliminating reliance on manual processes or informal information collection.

Experts describe this system as a seamless integration across multiple transport modes, where physical operations are supported by technologies such as IoT sensors, data analytics, computer vision, digital twins, and, in some cases, autonomous or semi-autonomous vehicles. Direct human interaction is reduced to the minimum necessary, while business rules, operational roles, and process flows are clearly defined and automated.

Furthermore, a fully digitalized system is characterized by being secure, efficient, and associated with minimal waiting times, eliminating bottlenecks, unnecessary checkpoints, and congestion throughout the goods and passenger movement chain. Digitalization enables traffic flows to behave in a continuous and orderly manner, comparable to a "pipeline" through which movement occurs efficiently.
From the user perspective, this system provides continuous digital assistance, delivering real-time updates on origin, journey, and destination conditions through in-vehicle guidance, automated notifications, and digital platforms. This results in on-time deliveries, high user satisfaction, a reduced carbon footprint, and full process transparency.

Overall, expert perspectives define a fully digitalized transport system as an integrated, automated, and data-driven ecosystem, capable of optimizing operations, anticipating disruptions, and ensuring efficiency, sustainability, and reliability across the entire mobility and logistics system.

New Skills and Training Required for Transport Professionals in a Digital Future

Expert responses agree that the digital future of the transport sector requires a balanced combination of technical capabilities, operational knowledge, and transversal skills, going beyond training focused exclusively on technology.

Experts consistently highlight data analytics as a foundational skill. Transport professionals will need to be able to interpret data, use dashboards, understand operational metrics, and support evidence-based decision-making, regardless of their specific role. At more advanced levels, machine learning, data engineering, and data science are identified as relevant, particularly for the development and evaluation of analytical and predictive models.

There is also a strong emphasis on the need for familiarity with digital platforms and sector-specific operating systems, such as PCS, APIs, real-time visibility tools, digital documentation, and systems supported by IoT and automation. For transport operators, such as drivers, experts stress the importance of basic skills in the use of electronic devices and operational software, adapted to their functional context.

Experts further underscore the importance of understanding legal and regulatory frameworks, as well as the real-world dynamics of freight movement, different cargo types, and the interaction among the multiple actors within the system (authorities, law enforcement, operators, and companies). This domain knowledge is considered essential and a prerequisite for any effective application of digital technologies or artificial intelligence.

In parallel, responses emphasize that soft skills are as critical as technical skills. Capabilities such as critical thinking, problem-solving, change management, stakeholder coordination, and effective communication are consistently mentioned as indispensable for leading and sustaining digital transformation processes in complex and fragmented environments.

Finally, several experts note that, in addition to acquiring new competencies, it is necessary to reduce fears and resistance toward digitalization through basic training materials and awareness programs for communities and users. In this context, the use of AI tools as reliable support mechanisms is valued, provided they are understood as a complement to human judgment rather than a substitute for expert knowledge.

Overall, expert perspectives indicate that capacity development for the digital future of transport must be multi-level, role-oriented, and progressive, integrating technical skills, operational domain expertise, and human competencies to ensure the effective and sustainable adoption of digital technologies.

SESSION VI OVERVIEW OF BEST PRACTICES, METHODOLOGIES, AND TECHNOLOGIES UTILIZED BY APEC ECONOMIES.

During this session, participants were divided into three groups, each guided by an expert moderator, who compiled and synthesized the insights generated by the team members. The discussion included techniques, practices, and methodologies that could be effectively automated, along with the relevant technologies and Artificial Intelligence models involved. Key obstacles and challenges identified during the discussions were also identified. The following items were discussed in all groups and responses and comments from participants are summarized as follows:

1. AI applications that most effectively reduce traffic

- Predictive congestion forecasting: Use time-series machine learning and hybrid models (statistical + ML) to forecast short-term (minutes–hours) and medium-term (days) congestion, accounting for seasonality, scheduled vessel arrivals, weather, and holidays. Outputs drive proactive measures (rescheduling, buffering, dynamic quotas).
- Appointment/slot systems and dynamic scheduling: Integrate predictive outputs into Truck Appointment Systems (TAS) and PCS so arrivals are staggered. Make slots enforceable via gate logic or strongly incentivized with pricing/priority; allow dynamic rescheduling when forecasts change.
- Computer vision for field sensing: Deploy low-cost cameras + YOLO-style detectors and custom geofence logic to measure lane occupancy, detect seal tampering, count vehicle clusters, and derive “graphical” occupancy metrics where GPS is missing or jammed.
- Optimization & routing: Use optimization (simulated annealing, genetic algorithms, integer programming) to assign arrival windows, parking, tow scheduling, and crane allocation, with fast re-optimization for incidents.
- Digital twins & simulation: Build small digital twins of yards/approaches to test rules, appointment policies, and layout changes before deployment; couple twins with real data for validation.
- Risk-based inspection & document automation: Combine OCR/IDP, manifest matching and CV/X-ray analytics to reduce unnecessary customs stoppages and prioritize true risks.

2. Data collection, integration and quality

- Essential data types: vehicle GPS traces, CCTV/RTSP streams, gate timestamps, manifest/e-manifest data, terminal yard positions, vessel ETAs, weather/sea state, road counters and toll station logs, and operator/manual logs.
- Data pipeline design: Ingest at appropriate frequency (seconds for vehicle GPS, minutes for aggregated counts), store in a data lake with strict metadata, and provide APIs for model training/real-time inference.
- Data augmentation & synthetic data: For scarce modalities (X-ray, rare events), use synthetic augmentation to train models; for vision, collect diverse weather/lighting examples or simulate them.
- Interoperability: Adopt common schemas and open APIs (or translate via middleware) so PCS, customs, terminal TOS, and city ITS can share canonical datasets.
- Handling intermittent data: Buffer local device data (app packs) and reconcile upon connectivity recovery; treat sensor fusion probabilistically to handle gaps.

3. **Operational implementation and workflows**
   - Pilot scope: Start with a narrow, bounded use case (single gate, single terminal, one commodity class) and a limited carrier list to maximize compliance and measurable impact.
   - Gate & yard changes: Automate ID checks (Optical Character Recognition/Automatic Number Plate Recognition - OCR/ANPR), integrate with TAS so slots are enforced by barrier control, and route vehicles to buffer/zoning areas to smooth peaks.
   - Human-in-the-loop design: Present AI outputs as prioritized windows or bounding boxes for operators; keep override pathways and explainability dashboards to build trust.
   - Incident handling: Implement rapid re-optimization and alerting channels (driver app, dispatcher messages) to reroute vehicles or move them to buffer parking when disruption occurs.
   - KPI alignment: Monitor throughput, average wait, queue length, assignment accuracy, false-positive inspection rates, and environmental KPIs (idle time, emissions).

4. **Border crossings — specific considerations**
   - Pre-arrival verification: Require e-manifests and advance electronic documentation to allow pre-screening and risk scoring before arrival, reducing on-site processing.
   - Roadside ITS: Equip approaches with ITS lanes, sensor arrays and message signs to segregate traffic flows by commodity/priority and to route vehicles to the right bay.
   - Segregation and resilience: Design separate inspection bays for long/complex checks to prevent single-bay blockages; use historical variability (not only averages) for capacity planning.
   - Cross-jurisdiction governance: Standardize risk rules and data exchange across jurisdictions (e.g., bilateral agreements such as Free and Secure Trade or FAST CBP program), with digital licensing or federated identity for trusted participants.

5. **Air cargo and busy airports (El Dorado use case)**
   - Common cargo community platform: Implement or federate a shared air-cargo PCS where trucking companies, handlers and carriers post ETA intents and cargo statuses; feed the platform into TAS and gate controls.
   - Driver engagement & trust: Reduce friction by integrating with carrier dispatch systems or lightweight background apps; provide clear commercial incentives (reduced dwell fees, priority windows) to encourage participation.
   - Wayfinding and terminal navigation: Use CV and geofencing inside terminals to reduce internal circulation time and prevent lost trips inside large cargo complexes.
   - Capacity & economic modeling: Demonstrate economic benefit across the chain (payer of wasted truck hours vs. beneficiary) to unlock funding and cooperation.

6. **Simulations, research & university roles**
   - Safe experimentation: Use campus simulation labs and digital twins to test algorithms, assess sensitivity to seasonality and incidents, and tune parameters before live pilots.
   - Synthetic data generation: Universities can produce labeled datasets, synthetic X-ray or rare-event samples, and open benchmarking tasks to accelerate model development.
   - Collaboration channel: Universities can act as neutral aggregators for multi-stakeholder pilots, offering evaluation, transparent metrics, and training programs.

7. **Technology stack & connectivity**
   - Sensor mix: Favor hybrid sensing—carrier GPS where available, low-cost cameras for corridor occupancy, toll/booth logs, and selective higher-grade sensors where needed (Light Detection and Ranging -LiDAR for yard mapping).
   - Edge + cloud: Run lightweight detectors at the edge for latency-sensitive tasks (ANPR, occupancy), stream metadata to cloud for aggregation, forecasting and digital twin updates.
   - Network choices: Use 5G/4G/LTE for high-bandwidth RTSP streams where available; use LoRa/LPWAN for low-bandwidth telemetry in specific use cases; plan for wired fallbacks in

critical zones.

- Open-source + managed services: Begin with open, well-supported models (You Only Look Once - YOLO, Open Neural Network Exchange - ONNX runtimes), orchestration tools (Airflow/Kubeflow), and incrementally use managed cloud services for scale.

8. Institutional, legal and workforce issues

- Data governance framework: Create multi-agency agreements that define data ownership, access levels, retention, privacy protections, and acceptable uses (privacy-by-design).
- Regulatory modernization: Work with customs and transport ministries to amend rules enabling automated clearance, appointment enforcement, and interoperable e-manifests.
- Workforce transition: Run capacity building (operators, customs examiners, data stewards) and co-design pilots with unions to reduce fear of job loss and shift workers to higher-value roles.
- Incentives & compliance: Use a mix of soft incentives (discounted fees, priority) and operational enforcement (gate access linked to valid appointments) to improve participation.

9. Financial models and sustainability

- Shared infrastructure funding: Encourage co-investment by terminal operators, port authorities and government for common sensors and data platforms to capture network benefits.
- PPP and user-fee approaches: Explore pay-for-service models (slot fees, performance rebates) or PPPs for phased rollouts; use short pilots to build an investment case based on measured savings.
- External financing: Leverage international development financing (Asian Development Bank, World Bank) or green bonds where congestion reduction yields measurable emissions savings.
- Total cost of ownership: Budget for ongoing maintenance, data storage, cybersecurity and model retraining—don't treat AI as a one-time purchase.

10. Practical rollout roadmap (stepwise)

- Inventory existing data and pain points; define clear problem statements and KPIs.
- Run a bounded pilot (single facility, limited carriers) using hybrid sensing (carrier GPS + cheap cameras + gate logs).
- Validate predictive model performance and economic benefit; iterate with operators.
- Expand scope: add more gates, corridors, and integrate customs/PCS systems; strengthen governance.
- Scale regionally with interoperable APIs, shared funding, and cross-border agreements.

11. Cross-cutting technical cautions and best practices

- Use hybrid models: combine simple probabilistic models and rules for robustness with ML for patterns too complex for rule-based logic.
- Monitor drift & incidents: implement continuous monitoring (data drift, concept drift) and rapid retraining pipelines (incremental learning).
- Design for partial adoption: systems must be robust when only a subset of carriers participates; use CV and corridor sensing to fill coverage gaps.
- Emphasize explainability: outputs must be interpretable for operators and stakeholders to accept automated recommendations.

12. Recommendations for next steps and collaboration

- Identify 2–3 candidate pilot sites (airport gate, port buffer zone, border crossing approach) and secure carrier/operator partners.
- Create a small cross-agency governance working group to define data sharing rules and KPIs.
- Assign university/research partners to build simulation environments and synthetic datasets for model tuning.
- Run 3–6 month pilots with clear evaluation criteria and a plan for incremental scale if KPIs show benefit.

SESSION VII. IMT - LABVAT: A DEDICATED RESEARCH FACILITY SPECIALIZING IN TECHNOLOGY AND ARTIFICIAL INTELLIGENCE TO MITIGATE TRAFFIC CONGESTION.

Computer Vision to Optimize Customs Operations, by Dr Rodrigo Ramos, National Autonomous University of Mexico

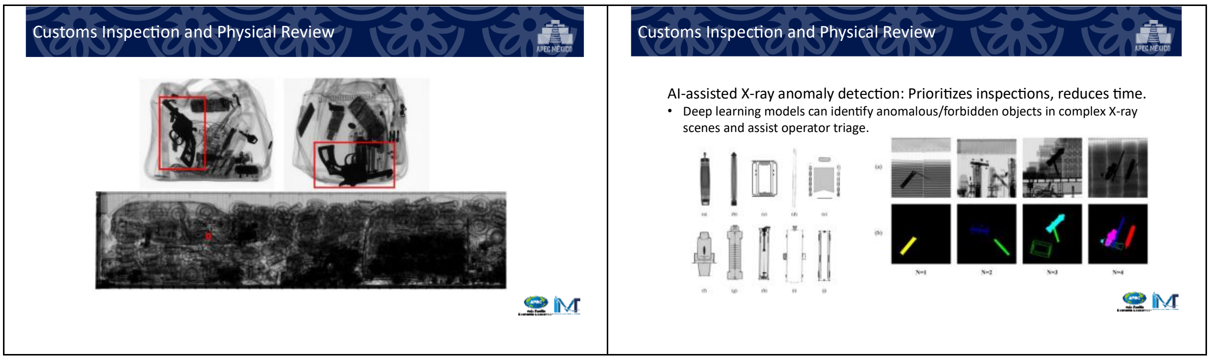
Dr Rodrigo Ramos opened his keynote by situating the audience in the operational crisis facing Mexican ports and customs. He described striking examples of fragility, the formation of long queues, sharp spikes in wait times (he cited the extreme case of Lázaro Cárdenas reaching as much as eleven days), and substantial economic impacts such as estimated manufacturing losses of roughly USD150 million during disruptive episodes. Ramos acknowledged recent modernization claims by authorities—new X-ray scanners purchased in 2023 and increased revenue collections—but argued that those improvements focus mostly on enforcement and collection rather than on end-to-end flow and road congestion, which are central to trade facilitation. Framing his talk against global trade facilitation, Ramos stressed that the objective must be a balance: preserve security while making trade faster and more predictable.

Graphic 19. Intelligence for Balanced Risk Management

From that starting point he moved into the central argument: computer vision (CV) and related AI techniques can materially reduce bottlenecks, accelerate inspections, and simultaneously improve security. Rather than present only theoretical research, Ramos emphasized applied, incremental modernization, beginning with sensors and analytics and evolving toward orchestration and predictive automation, while keeping humans at the core of decision-making. He illustrated how relatively modest investments in camera systems, ANPR, facial biometrics, container ID recognition, and object detection in X-ray imagery can unlock changes in throughput that compound when these systems are integrated. Drawing on international examples, he noted reports of dramatic throughput improvements after biometric and ANPR deployments. One real-world account showed throughput increasing from roughly 20 vehicles per hour to more than 120, and a case from Israel's Ashdod port where automation reduced handling time by 15–20 minutes per vehicle per operator. Such examples, he said, demonstrate that these are not purely cultural or isolated phenomena: well-orchestrated automation yields measurable gains across varied contexts.

Ramos then addressed one of the most technically challenging aspects of customs inspections: detecting small or hidden threats inside containers using X-ray imagery. He compared the problem to airport luggage screening and pointed out that containers are orders of magnitude harder; the threat can occupy less than one percent of the field of view, making detection a "needle-in-a-haystack" problem. He explained how the field has moved from traditional machine-learning approaches, hand-crafted image statistics and models such as random forests that can handle coarse tasks like detecting empty containers or cars, to deep convolutional networks that are necessary to find small metallic threats such as weapons or hidden contraband. However, Ramos emphasized that deep networks require large amounts of data and that data scarcity remains the primary bottleneck.

Graphic 20. Customs Inspection and Physical Review



To address this, he described two practical strategies. The first is the creation and augmentation of synthetic data: X-ray scans of danger objects, such as weapons or sections of nuclear centrifuges, are projected onto various container X-ray scenes in various orientations and stackings. These synthetic composites are then used to expand training datasets. The second strategy is self-supervised or anomaly-detection learning: teach models what "normal" cargo looks like so that deviations are automatically flagged for human inspection, reducing dependence on exhaustive labeled threat datasets. He illustrated the need for smart augmentation with a personal anecdote from his ultrasound research: a model reached high accuracy by learning a template rather than true variation in anatomy, and only through deliberate augmentation (rotation, scaling, translation) did it generalize properly. Ramos used this to stress that accuracy alone can be misleading; qualitative assessment and robust testing are essential.

These technical building blocks feed into operational workflows that Ramos laid out in two common patterns: assisted selection and assisted inspection. In the assisted selection flow, full-load X-ray images are preprocessed by AI, which performs a risk assessment, triggers random sampling, and incorporates intelligence alerts; operators then receive small, focused bounding boxes or windows highlighting regions of interest, akin to inspecting a backpack rather than scanning an entire container. This prioritization dramatically reduces the time human operators spend per container while preserving oversight. The assisted inspection flow builds on selection by combining document-analysis techniques, OCR and intelligent document processing (IDP), to cross-check manifests against visual and X-ray evidence. Ramos described how integrating manifest OCR, cargo photos and video analytics, IoT sensors, and X-ray analysis produces a richer, faster verification process that saves minutes per load and reduces manual errors.

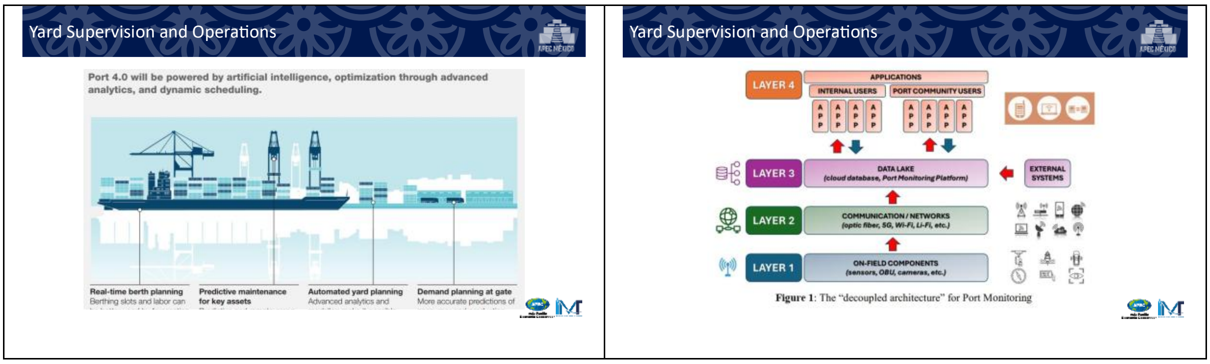
Beyond inspection, Ramos explored broader port orchestration topics. Cameras and video analytics can detect seal tampering, broken or missing seals, and produce automatic alerts with timestamp and location so that manual checks, major sources of delay, are minimized. Smart yard supervision systems harness video analytics and IoT telemetry to reroute trucks, reschedule towing, adjust parking allocations, and prioritize high-value loading, moving operations from reactive to predictive. He described how coordinated vehicle and yard orchestration can approach the dramatic time savings reported in Roll-On/Roll-Off automation examples. One Spanish port case claimed up to a 70 percent reduction in processing time through careful orchestration, though he tempered expectations by noting context dependence and implementation complexity.

Ramos also sketched a practical architecture for modernization, organized in four layers. The field layer comprises sensors, cameras, X-ray scanners, and edge compute nodes. Communications form the next layer, whether wired, 5G, or low-power wide-area networks like LoRa, supporting reliable data transfer. The data-integration layer requires cloud or hybrid data lakes and orchestration to avoid silos and enable cross-system analytics. Finally, the application layer offers role-based dashboards and apps: drivers need appointment and alert apps; operators need explainable dashboards that show risk-scored views and allow overrides; administrators need port-community-system integration. He argued that many early deployments can be built on open-source components and that digital twins, virtual replicas of a terminal, enable simulation, planning, and predictive scheduling. On optimization techniques for scheduling and appointment systems, he mentioned genetic algorithms and simulated annealing, even speculating on potential uses of quantum annealers for hard combinatorial problems.

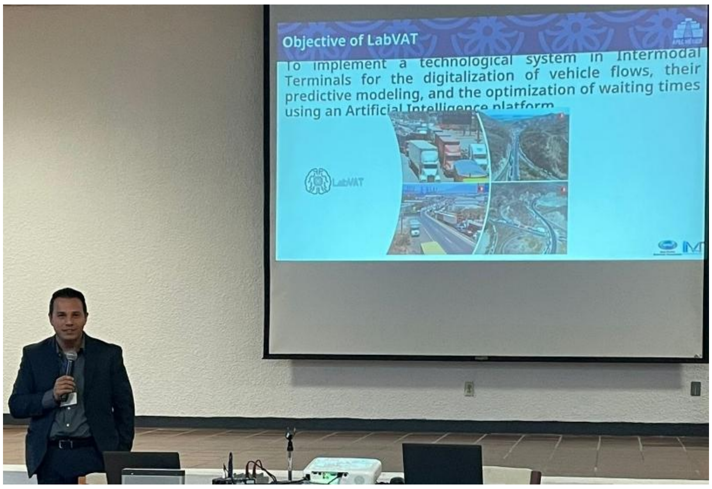
Throughout the talk Ramos returned to governance, human oversight, and interoperability. He emphasized that AI should augment, not replace, human decision-making: systems must present explainable cues, maintain auditable logs, and allow operator intervention. Interoperability between modules (biometrics, ANPR, X-ray detection, OCR) requires clear interfaces and shared risk-scoring logic to avoid fragmentation. He also noted complementary technologies such as blockchain for secure, auditable recording of transactional events and suggested that recorded efficiency gains could be translated into carbon credits, adding environmental and economic incentives to modernization.

Ramos concluded by framing the transformation as a strategic investment aligned with APEC commitments and domestic goals: start with sensors and incremental analytics, use synthetic and self-supervised methods to overcome data scarcity, deploy role-based applications and dashboards that keep humans in the loop, and progressively move toward orchestration, predictive maintenance, and digital twins. If pursued pragmatically, he argued, computational vision can significantly reduce bottlenecks, raise throughput, enhance transparency and security, deliver economic benefits, and reduce environmental impact, turning port modernization from an operating expense into a competitive, prosperity-enhancing strategy for Mexico.

Graphic 21. Yard Supervision and Operations



Integrating Artificial Vision with Intelligent Transportation Systems: The LabVAT Methodological Framework for Mitigating Congestion in Loading and Unloading Zones, by Dr Alejandro Ascencio, Mexican Institute of Transportation



Dr Alejandro Ascencio opened by explaining the LabVAT initiative at the Mexican Institute of Transportation: a compact, portable laboratory that integrates artificial vision with intelligent-transport systems to mitigate congestion in loading and unloading zones. He positioned LabVAT as an evolution from classic digital image processing—where object detection required motion detection, segmentation, and only rudimentary classification—toward today's AI-driven pipelines in which off-the-shelf detection models and intelligent agents enable continuous, robust decision-making. The lab's design goals are practicality and low cost: modular software that can move between environments, scale vertically or horizontally, and run on inexpensive sensors and consumer-grade cameras when needed.

Ascencio motivated the work with the urgent operational reality in Mexico—Manzanillo was cited as a stark example of extreme queues and wasted trips when drivers arrive hours early only to find long delays. That operational waste and the resulting congestion became the problem LabVAT targets: predict traffic flows to optimize vehicle assignments and appointment times at intermodal terminals and loading/unloading areas, delivering dynamic, real-time recommendations to minimize queueing and idle time.

He described the system architecture as deliberately simple and lightweight. Vehicle positions are obtained either from GPS-equipped trucks or, where GPS is missing, via a background mobile app that packages and forwards location updates when connectivity returns. Real-time video streams (RTSP) feed inexpensive vision models—Ascencio noted they use YOLO as a readily available detector—augmented with custom logic such as virtual geofences and de-duplication rules so detections are counted correctly. The lab's "smart module" fuses three inputs: current vehicle positions, travel-time estimates from providers like Google or Here, and a visual estimate of road occupancy derived from AI, producing an arrival status and predicted arrival time for each assigned vehicle.

A notable technical detail he explained is LabVAT's traffic metric: rather than simply counting vehicles, the vision module converts pixel clusters into a probabilistic density (Gaussian peaks) that reflects vehicle spacing and road occupancy. This graphical traffic measure, combined with measured speeds, produces a compact representation used by prediction models. For forecasting, Ascencio presented experiments with neural networks trained on about 36,851 records and showed that models can capture seasonality and produce usable two-hour forecasts. He emphasized that training was computationally intensive (many experiments taking days), but inference runs in real time once models are deployed.

For assignment and scheduling, the lab applies stochastic optimization (simulated annealing) to recommend which vehicles should depart and when so they arrive when queues are minimized. In demonstration experiments the system reduced total waiting times dramatically in best-case trials (from around 19 hours to under 6 hours in aggregate scenarios). Validation is visual and quantitative via dashboards that show monitored vehicles, predicted arrivals, and model error—Ascencio reported average assignment errors on the order of ±3 vehicles in their testbed and highlighted areas for future stress-testing on denser road sections.

Beyond arrival prediction and assignment, Ascencio outlined additional LabVAT capabilities: detecting passage events (useful when GPS is jammed), identifying route deviations for safety, and a lightweight fleet-allocation module that recommends which vehicle to dispatch to which demand based on volumetric weight and fleet availability. He stressed the lab's low-cost ethos—examples include USD30 cameras and background-position apps that store and relay data when connectivity returns—because scalability and affordability are central to real-world adoption in Mexico and similar contexts.

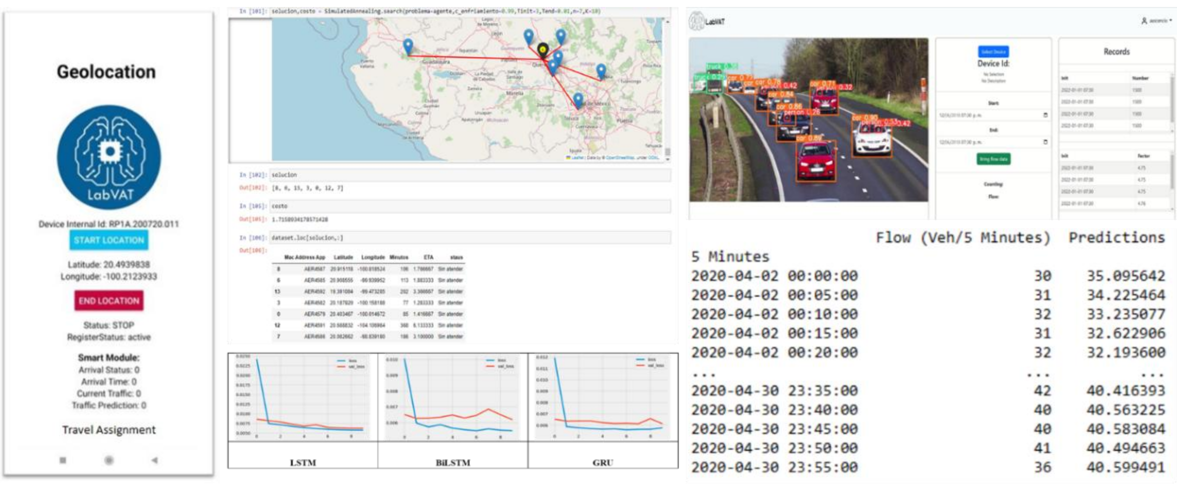
Throughout, Ascencio returned to the lab's philosophy: combine practical, low-cost sensing with modular AI that keeps human operators in the loop via clear dashboards and straightforward apps. He invited workshop experts to test and critique LabVAT so the methodology can mature and generalize beyond the initial cases. In closing he reiterated the core promise: by fusing affordable vision, IoT, predictive models, and stochastic optimization, LabVAT can materially reduce wait times, cut congestion and emissions, and offer a scalable platform for improving operations at intermodal terminals and loading/unloading zones.

The following graphic provides an overview of the main functionalities of LabVAT. It shows the geolocation application, which enables the identification of the position of units assigned to loading and unloading zones. In addition, the intelligent module is displayed, where the current traffic conditions obtained from the computer vision system can be visualized, along with the estimated arrival time considering traffic congestion, the arrival status through virtual geofences, and the time recommended by the intelligent agent (leftmost image).

Additionally, an experiment on unit assignment is presented, in which 7 out of a total of 28 units are allocated to the intermodal terminal. It should be noted that this assignment depends on the current location of the units, their estimated arrival time considering traffic conditions, and their assignment status (central image).

Finally, the experimentation of the computer vision system is shown, illustrating the vehicle detection and classification process, as well as the calculation of the traffic factor, which constitutes one of the main inputs for the prediction model (rightmost image).

Graphic 22. Representative image of the integrated LabVAT system.



LabVAT Q&A Session.

The Q&A after the LABVAT presentation turned into a practical, wide-ranging discussion about deployment, data sources, validation, governance and near-term pilots. Multiple participants framed the LabVAT work against real operational needs, most prominently El Dorado Airport, asking whether the lab could be crash-tested in high-volume environments (1,200–2,000 trucks/day) and advising that a focused pilot at a single terminal or airport gate (with a known, limited set of carriers) is the fastest path to useful results.

A recurring theme was data source pragmatism. Several speakers proposed leveraging smartphones and existing messaging platforms (WhatsApp, Meta APIs) and traffic providers (Google, Here) to obtain live positions and ETA estimates rather than installing new IoT hardware immediately. Alejandro and others cautioned about reliability: device shutdowns, jammers, and privacy settings can make crowdsourced location data intermittent or biased. The group recommended a hybrid approach, use carrier-supplied GPS where available, supplement with inexpensive video/YOLO detection and virtual geofences where positioning is missing, and package/store offline GPS bursts for later upload when connectivity returns.

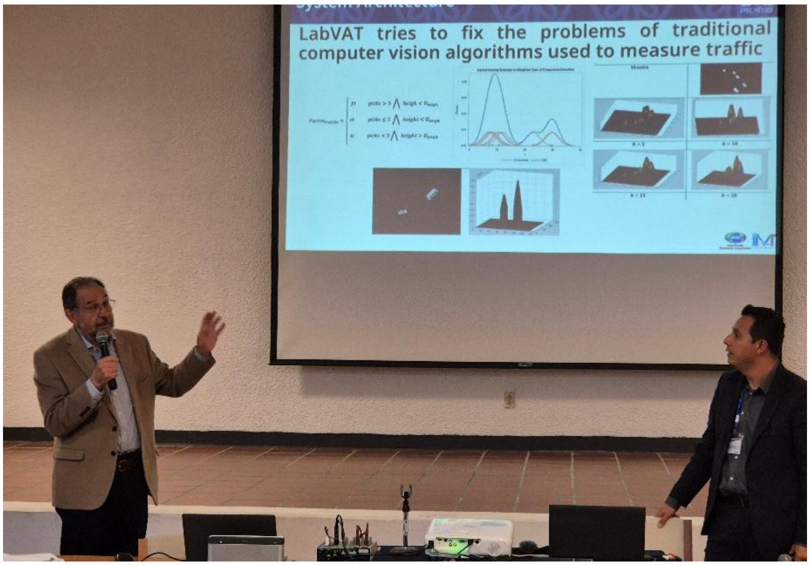
Participants raised technical questions about the LabVAT models. People asked whether the forecasting neural nets compared to simpler methods (Markov, recurrent nets) and how models handle seasonality, weather, or incidents. Alejandro acknowledged heavy offline training (many experiments) and said incremental learning and retraining can adapt models to changing conditions; the lab uses simulated annealing for assignment and emphasized the need for fast re-optimization when disruptions occur. The practical meaning of the reported ±3-vehicle error was queried; the response clarified that the lab's operational metric is not raw vehicle counts but a congestion class (low/moderate/high) and that prediction error must be interpreted in context (service capacity, buffer zones, and whether errors materially affect scheduling or create unnecessary movement).

Operational control and human workflows were heavily discussed. Several attendees emphasized appointment/slot governance: if the system is applied to a single port/terminal, operators can require participation from known carriers and obtain high compliance and data completeness. Examples from existing port systems were cited where gate readers, Community Emergency Alternative Response (CEAL)-style pretriage, and integrated customs/terminal systems enforce lifecycle states (available/cleared) and open barriers only when the load is ready, showing how LabVAT outputs could feed established orchestration. Concerns about drivers leaving trucks or dispatchers changing routes were acknowledged; the lab's routing/diversion modules and operator alerts were presented as mitigations, but participants stressed that business-rule alignment and carrier cooperation are essential.

Privacy, governance and regulation surfaced repeatedly. Several voices urged caution about relying on third-party platforms for core tracking due to privacy opt-outs, spoofing, and unreliability; legal/regulatory frameworks are still nascent in many economies, so consent, data governance, encryption and tokenization (or incentive mechanisms) should be considered. Proposals ranged from voluntary incentives (discounts, tokens) to mandatory device activation tied to assignment, possibly enforced by gate logic or by institutional policy for assigned shipments.

Practical resources and partnerships were proposed. Attendees offered access to existing camera feeds (departmental, highway/Arco Norte, airport CCTV) and suggested institutional pilots via a limited set of carriers or via academic consortiums. Financing and scaling routes were discussed: IMT-related laboratory programs, copyright/patent pathways, and pragmatic choices to keep costs low (cheap cameras, background GPS apps, open-source models) to make pilots affordable.

Finally, the group converged on actionable next steps: prioritize a narrow pilot (one terminal/one facility), combine carrier GPS and lightweight vision to reach high coverage, validate predictions against operational KPIs (wait time, throughput, buffer utilization), develop governance rules for appointments and enforcement, and iterate with incremental machine-learning updates. Participants volunteered technical contacts and data sources for immediate collaboration, and several urged rapid prototyping using available camera feeds and carrier lists rather than waiting for full infrastructure rollouts.



LabVAT Survey Responses

After Dr Ascencio's presentation, a survey was distributed electronically to the workshop participants. The survey questions are presented in Appendices V and VI. Based on the comprehensive analysis of all survey responses, and considering all participants as subject-matter experts, the following synthesis reflects a high level of technical maturity, convergence of opinions, and international relevance. Respondents represent logistics operators, academic institutions, port authorities, government agencies, and consulting firms across multiple APEC economies.

Overall Assessment of LabVAT

The session received a high level of satisfaction, with the majority of experts rating it as *"Very Satisfied"* or *"Satisfied"*. Participants recognized the strategic relevance, clarity of vision, and applied focus of the LabVAT. The initiative was widely perceived as well aligned with current challenges in urban mobility, freight transport, and trade-related traffic congestion.

Key Technological Priorities Identified

Experts consistently highlighted the importance of the following technological pillars:

- Computer vision and video analytics for traffic monitoring, infrastructure assessment, and vehicle behavior analysis.
- Artificial intelligence and machine learning for congestion prediction, decision support, and traffic flow optimization.
- Drones and IoT technologies, particularly for last-mile logistics and infrastructure monitoring.
- Multisource data integration, including data from city governments, transport agencies, ports, and logistics operators.

These technologies are viewed as critical enablers for more efficient, safer, and more sustainable transport systems.

Engagement with Governments and Public Stakeholders

There is strong consensus among experts that LabVAT should:

- Actively collaborate with city governments and transport authorities, leveraging real-world operational data.
- Demonstrate measurable and tangible benefits, such as reductions in congestion, travel times, and logistics costs.
- Position itself as a neutral, technology-driven platform supporting evidence-based public decision-making.
- Serve as a bridge between research, public policy, and operational implementation.

Expected Impact

From an expert perspective, LabVAT has the potential to:

- Become a regional reference platform for AI-driven mobility and logistics solutions.
- Operate as a demonstration laboratory, enabling scalability and replication across APEC economies.
- Support data-driven transport policies aimed at mitigating trade-related road congestion.

Conclusion

In conclusion, experts agree that LabVAT addresses a real and pressing need, is supported by a robust and forward-looking technological approach, and holds strong potential to deliver meaningful impacts in reducing road traffic congestion related to trade, provided that close collaboration with public stakeholders is maintained and real-world results are consistently demonstrated. The detailed response to survey questions is presented in the following table.

Thematic Axis	Key Expert Responses (Converging Views)	Identified Relationship / Interpretation
Overall perception of LabVAT	High satisfaction levels (*Very Satisfied / Satisfied*). LabVAT is perceived as relevant and timely.	Strong alignment between expert expectations and LabVAT's objectives, confirming its credibility and regional relevance.
Core technologies	AI, machine learning, computer vision, video analytics, drones, IoT.	Consensus that advanced data-driven technologies are central to addressing congestion and logistics challenges.
Primary application areas	Traffic monitoring, congestion prediction, infrastructure analysis, and last-mile logistics.	Technologies are directly linked to real-world transport and trade-related use cases.
Data importance	Need for access to government, city, and operational transport data.	Effective AI solutions depend on multisource, real-time, and institutional data sharing.
Engagement with governments	Collaboration with city governments and transport agencies is essential.	LabVAT is positioned as a facilitator between public institutions and advanced analytics.
Value proposition to public sector	Deliver measurable benefits (reduced congestion, lower costs, better planning).	Demonstrating tangible outcomes is critical for institutional adoption and scalability.
Role of LabVAT	Neutral technical platform, research-to-implementation bridge.	LabVAT is perceived as an applied laboratory rather than a purely academic initiative.
Scalability and replication	Potential to expand solutions across cities and APEC economies.	Experts see LabVAT as a reference model for regional replication.
Contribution to trade-related traffic reduction	AI-driven optimization supports smoother freight flows.	Direct relationship between technology deployment and reduction of congestion linked to trade activities.

LabVAT Observations: non-in-Person mode

The survey was sent to various economies that were not physically present at the Workshop. The responses that were received are summarized below.

Canada

Digital Infrastructure
From a digital infrastructure perspective, Canada would likely be positioned at Level 2 or 3 in terms of implementation feasibility. While the economy generally benefits from strong connectivity, certain remote regions may face limitations in digital infrastructure. However, these regions are also less likely to experience congestion, meaning that the impact on the overall effectiveness of the platform would likely be minimal. Nevertheless, it is not possible to provide a definitive assessment regarding the availability or quality of transportation data.

Urban Congestion Challenges
Major Canadian cities experience significant levels of congestion, particularly in central urban areas and along key port and airport corridors. This situation reduces economic productivity and may weaken public confidence in government institutions.

Fiscal Constraints
Most levels of government in Canada are currently facing fiscal pressures. As a result, large-scale capital investments may be difficult to justify unless they are supported by clearly defined and measurable benefits.

Cybersecurity Requirements
Any proposed solution would need to undergo a rigorous cybersecurity assessment. Data that is operationally valuable is often also attractive to adversarial actors, making the implementation of robust safeguards essential.

Strategic Alignment
The project aligns with Canada's broader strategic objectives, including leveraging artificial intelligence to enhance competitiveness and position it as a leader in economic growth among G7 economies.

Additional Comments
For an AI-based solution to be effective, the use of large-scale data would be required. It is not clear how adoption of the system could be encouraged or mandated among diverse operators (e.g., trucking companies, ports, airports, and railways), which represents a significant adoption risk.

A deployment in throughout Canada, even if limited to major cities could entail high capital costs, particularly related to the installation of cameras and supporting infrastructure around intermodal facilities.

There are privacy considerations associated with GPS tracking of trucks and drivers. These concerns could potentially be mitigated by integrating the system with existing Electronic Logging Device (ELD) regulations, which already capture certain location data, rather than introducing a new standalone tracking mechanism.

The prediction model may have inherent limitations in anticipating sudden traffic disruptions (e.g., severe weather conditions, vehicle breakdowns, or collisions). Improving accuracy would require substantial volumes of real-world training data.

Some operators and government agencies in Canada have already developed similar pilot projects, such as:

- Implementation at the Port of Vancouver (Amazon Web Services - AWS – Deloitte)
- Estimation of traffic volumes using roadside camera imagery to generate real-time data streams

Canada could benefit from this technology in and around major urban centers where camera infrastructure already exists. However, privacy concerns and adoption challenges would likely constitute the primary barriers to implementation.

Japan

Use of the CONPAS® System for Optimizing Container Terminal Operations (Case: Port of Yokohama, Japan)

At the Port of Yokohama, Japan, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), through its Kanto Regional Development Bureau, has implemented the CONPAS® (Container Fast Pass) system as a technological solution to improve the efficiency of container terminal operations.

CONPAS® is an access management and reservation system designed to reduce congestion at terminal gates, shorten trailer waiting times, and enhance productivity within the port logistics system. The system integrates information and communication technologies to proactively coordinate container entry and exit operations.

Its main functionalities include:

- Mandatory advance reservations for container entry and exit.
- Distribution and leveling of trailer arrival times to avoid concentration during critical time windows.
- Use of port security cards (PS Cards) to streamline access procedures and reduce manual data entry.
- Advance verification of entry and exit information, as well as the use of vehicle approach data to prepare containers in the yard ahead of trailer arrival.
- Coordination with the Terminal Operating System (TOS) to improve internal operational planning.

According to the document, as a result of pilot tests and continuous system operation:

- An approximate 20% reduction in processing time for outbound operations was achieved.
- Gate processing time was reduced by up to 60% (estimated).
- A reduction of approximately 10% in total trailer waiting time prior to terminal entry was observed.
- The implementation of a mandatory reservation scheme enabled the distribution and leveling of vehicle arrivals, directly contributing to reduced congestion at terminal gates.
- Yard operation efficiency improved by allowing advance preparation of containers prior to trailer arrival.

This case demonstrates that the adoption of reservation systems and intelligent access management solutions, such as CONPAS®, represents a replicable best practice for APEC economies to address port congestion, improve logistics efficiency, and strengthen international trade competitiveness through the strategic use of digital technology.

Chinese Taipei

The LabVAT Methodology, which integrates GPS positioning, image recognition, and traffic prediction modules to optimize freight vehicle scheduling, is beneficial for improving traffic conditions around airports, seaports, and multimodal transport hubs. Field validation conducted with freight operators demonstrates the system's feasibility, with acceptable prediction accuracy.

Observations and Suggestions for Reference

1. As the current trial involved only five trucks, we recommend expanding the test scale, particularly during peak freight periods (e.g., Mexican Independence Day, Day of the Dead, Christmas), and conducting stress testing of the LabVAT system.
2. Variations in loading and unloading times, as well as potential operational disruptions, should be incorporated into the model to enhance the realism of system predictions.
3. As image recognition may be affected by adverse weather or visibility conditions, we suggest integrating complementary data sources, such as mobile-based traffic information (e.g., Google Maps).
4. In cases of severe congestion caused by accidents, adding dynamic rerouting functions to the application could improve dispatch reliability.
5. Future system architecture should incorporate cybersecurity, data protection, and privacy management requirements to strengthen overall system reliability.

SESSION VIII: Conclusions, Recommendations and Final Remarks.

Conclusions

The technical analysis and case studies presented in this project confirm that trade-related road congestion in APEC economies is fundamentally a systemic and operational challenge, rather than a problem driven solely by insufficient physical infrastructure. Across seaports, airports, logistics corridors, and land border crossings, congestion frequently results from fragmented decision-making, information asymmetries, and limited institutional coordination. These conditions generate artificial demand peaks and suboptimal use of existing capacity, even where infrastructure is adequate.

Artificial intelligence was identified as a high-value enabler when applied to predictive and operational functions, particularly in areas such as arrival time forecasting, anticipation of congestion peaks, dynamic allocation of appointments and resources, route optimization, and scenario testing through digital twins. The discussions emphasized that AI solutions are most effective when deployed within hybrid architectures that integrate multiple data sources, such as GPS, IoT, computer vision, and administrative data, while retaining human operational oversight. Fully automated approaches were viewed as less viable in the current institutional and regulatory contexts of many APEC economies.

At the same time, the project highlighted that non-automated operational strategies remain critical, especially in heterogeneous environments with uneven levels of digital maturity. Practices such as time windows, manual assignments, and locally developed heuristics continue to play a central role in maintaining system functionality. Rather than being displaced, these practices should be documented, standardized where possible, and progressively digitalized, as they provide essential operational knowledge and training inputs for future AI-based solutions.

Digitalization emerged as a strategic enabler rather than a stand-alone solution. Technologies such as IoT, telematics, PCS, and appointment platforms deliver sustained benefits only when supported by clear governance arrangements, trusted data-sharing frameworks, interoperable standards, and robust cybersecurity mechanisms. Persistent trust gaps between public and private stakeholders, along with regulatory uncertainty, remain key barriers to broader adoption.

Finally, the project confirmed that the benefits of intelligent traffic and logistics management extend well beyond congestion reduction. The analyzed solutions contribute to lower emissions and energy consumption, improved road and operational safety, enhanced resilience to disruptions, and strengthened regional trade competitiveness. These outcomes align directly with APEC's cross-cutting priorities on sustainability, inclusive growth, and supply chain resilience.

Recommendations

Recommendations for APEC Economies

APEC economies are encouraged to prioritize data-driven and non-intrusive solutions as a first-line response to trade-related congestion, before committing to costly and time-intensive expansions of physical infrastructure. Predictive analytics, intelligent appointment systems, and digital twins offer the ability to unlock latent capacity in existing networks, often with lower investment requirements and faster deployment.

In implementing these solutions, economies should adopt hybrid human–AI operational models in which artificial intelligence supports, rather than replaces, human decision-making. Such models increase institutional acceptance, reduce operational risk, and allow systems to adapt to diverse legal, regulatory, and organizational contexts. They also enable a gradual transition toward more advanced smart mobility and smart logistics frameworks.

As an entry point, economies should deploy measurable and scalable pilot projects with a clearly defined scope, such as a single terminal, a logistics corridor, or a land border crossing. Each pilot should be designed around a small set of well-defined performance indicators, including waiting times, queue variability, throughput, and emissions, to generate quantitative evidence that can inform scaling decisions.

To enhance robustness and resilience, economies should pursue hybrid data strategies that combine multiple complementary data sources. Integrating GPS and fleet telematics (where available) with low-cost IoT sensors, computer vision leveraging existing camera infrastructure, and anonymized administrative datasets reduces dependence on any single data stream and improves the reliability of predictive models.

Institutional and Governance Recommendations

Effective implementation requires strengthened data governance and interoperability frameworks. APEC economies should advance data-sharing arrangements with differentiated access levels, promote common standards for logistics and traffic data, and establish clear cybersecurity and digital resilience policies that build confidence among stakeholders.

Public–private cooperation should be treated as an enabling condition rather than a parallel activity. Institutionalized logistics forums, community platforms, and co-financing mechanisms can support sustained collaboration among authorities, operators, concessionaires, and technology providers, ensuring continuity beyond political and administrative cycles.

Recommendations for APEC and the Transportation Working Group

At the regional level, APEC, through the Transportation Working Group, should scale the exchange of best practices and technical capacities by promoting repositories of replicable case studies, supporting targeted technical workshops, and facilitating cooperation between economies with different levels of digital maturity. Capacity building in the application of AI and data analytics for transport and logistics should remain a priority.

Finally, the findings of this project should be integrated into future APEC initiatives on trade facilitation, transport digitalization, sustainability, and supply chain resilience. Intelligent management of trade-related traffic should be recognized as a core component of resilient and competitive regional supply chains, rather than a stand-alone technical intervention.

Final Remarks

In this session, the moderator, Mr Juan Carlos Villa, requested key takeaways from all workshop participants. Most of the participants coincide in their comments which are summarized below:

1. **Strong endorsement of IMT and collaboration:** IMT's data and capacity position it as an ideal hub for regional pilots; public–private buy-in and customs engagement are essential, and the LabVAT output could enable a cargo marketplace by exposing capacity, flows and timing.

2. **Language/ mindset shift:** replace "problem" with "problem statement" to focus teams on solvable, scoped objectives rather than vague crises.

3. **Buy-in and use-case focus (researcher view):** success depends on demonstrating clear business value to carriers, terminals and authorities, not only academic merit, so prioritize concrete, stakeholder-relevant use cases.

4. **Governance and stakeholder sensitivity:** technology is advancing fast, but infrastructure and institutions turn slowly; solutions must balance innovation with privacy, proprietary interests and regulatory concerns.

5. **Data sharing and partnership (academic):** academics need access to operational data; private stakeholders need incentives and time, collaboration and knowledge-sharing are critical to scale research into practice.

6. **Opportunity for cross-border learning**: participants from other regions (e.g., Thailand) saw the concepts as transferable with local adaptation and valued the workshop for opening practical ideas and contacts.

7. **Communication and interoperability (practitioner):** the main barriers are human , communicating benefits to stakeholders and establishing data-sharing mechanisms so disparate systems (customs, carriers, terminals) interoperate.

8. **Collaboration mechanism (panel conclusion):** public–private cooperation is the key challenge and opportunity, sell benefits, show ROI to stakeholders, and build coalitions to adopt pilots.

9. **LabVAT as a starting point (computer-vision labs):** the workshop validated LabVAT as a practical starting platform; participants commit to share data and explore collaborations between vision labs and logistics associations.

10. **Practical pilot advice (operations**): begin with narrow, facility-level pilots (single terminal/limited carriers), leverage existing feeds/APIs and camera assets, and use governance (appointments, gate logic) to ensure high participation and measurable KPIs.

11. **Technical caution and suggestions:** prefer hybrid data sources (carrier GPS + vision) to handle jammers and privacy opt-outs; validate models across seasonality and incidents; use incremental learning and rapid re-optimization for disruptions.

12. **Low-cost, scalable emphasis:** prioritize affordable sensors, background mobile apps that buffer data, open-source models, and modular architectures so pilots remain affordable and portable.

13. **Enforcement & incentives:** combine voluntary incentives (discounts, tokens) with institutional rules (assignment-linked activation, gate enforcement) to improve data completeness and compliance.

14. **Hosts' and organizers' closing:** the event succeeded in knowledge exchange, created working relationships, and should be the first of many iterative forums to harmonize solutions across the region.

Summarizing, the consensus centered on practical, small-scope pilots that combine cheap sensing, hybrid data strategies, clear business cases for stakeholders, human-centered governance, and iterative machine learning workflows, supported by IMT as a convening platform to scale regionally.

APPENDICES

Appendix I Laboratory of Computer Vision and Intelligent Transportation Systems (LabVAT) Methodology

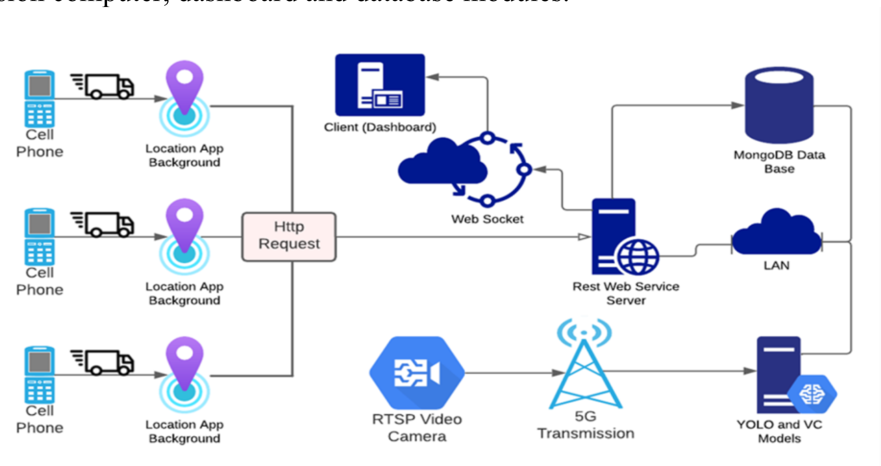
Objective of LabVAT

The **Laboratory of Computer Vision and Intelligent Transportation Systems (LabVAT)** aims to optimize traffic in loading and unloading areas — such as access roads to intermodal terminals, ports, and airports — through a system that:

- Predicts future traffic congestion.
- Generates departure and arrival itineraries from the geographical position of vehicles previously assigned to loading/unloading areas, in order to minimize waiting times.
- Automatically assigns trips based on service capacity and traffic conditions.
- Provides digital tools (mobile app and dashboards) for real-time decision-making.
- This system has received funding from the Mexico Digital Strategy Coordination (around USD38,900) on three occasions. This Mexican government agency serves as a platform that provides funding for technological projects focused on enhancing societal development in the economy.

Solution Architecture

The following diagram presents the system architecture that includes the location devices artificial vision computer, dashboard and database modules.



LabVAT Architecture

The following diagram illustrates the information flow within the LabVAT system architecture, integrating mobile applications, video streaming, and artificial intelligence models.

1. **Mobile Devices (Cell Phones):** Vehicle operators use a background location app that continuously sends GPS coordinates to the system.
2. **HTTP Request:** The location data is transmitted through HTTP requests, allowing real-time communication with the web service server.
3. **Rest Web Service Server:** This server manages incoming requests and distributes the data across the system. It interacts with the MongoDB database for storage and the LAN network for internal data exchange.

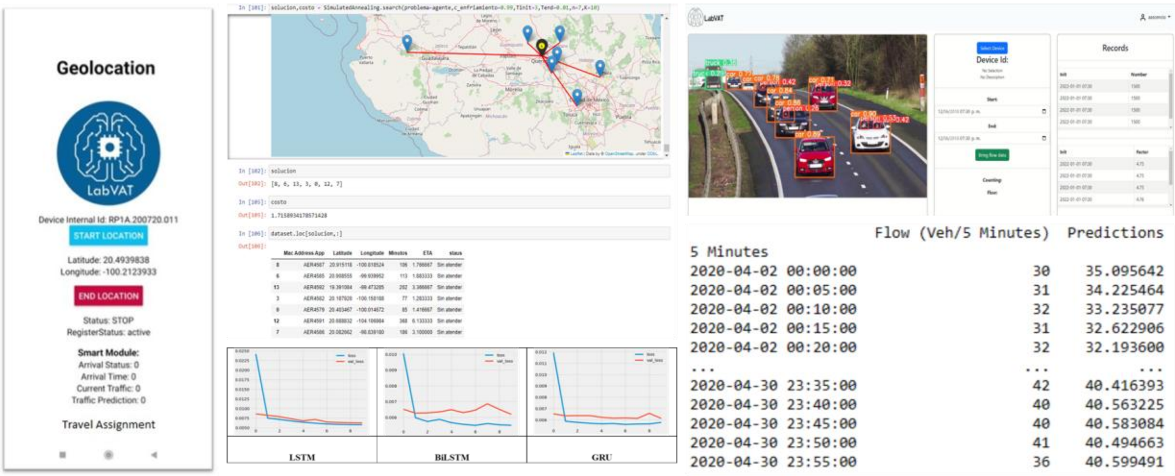
4. **WebSocket Communication:** A WebSocket channel provides bidirectional, real-time communication between the server and the client dashboard, which displays vehicle positioning, traffic status, and AI-generated recommendations.

5. **RTSP Video Camera and 5G Transmission:** In parallel, real-time video is captured by RTSP cameras and transmitted through 5G networks. This data is sent to the AI engine.

6. **YOLO and Computer Vision Models:** The video feed is processed by YOLO and other computer vision models, enabling object detection, tracking, and traffic flow analysis.

7. **Client Dashboard:** Finally, the integrated data (vehicle location, predictions, video analytics) is presented on the client dashboard, providing operators with real-time situational awareness and decision support.

The following figure depicts the main areas of the methodology



Representative figure of the LabVAT methodology

- **Right side:** a screenshot of the mobile application is shown, which connects the vehicle operator with the server. The app continuously reports the geographic position and provides key information such as the estimated arrival time to the loading/unloading zone, current traffic conditions, and the departure time assigned by Artificial Intelligence.
- **Upper center:** the assignment of half of the vehicles scheduled for the experimental day is displayed. This assignment, optimized through the **Simulated Annealing (SA)** algorithm, reduces waiting times by finding the best allocation of vehicles according to their arrival times.
- **Lower center:** graphs are presented to demonstrate the generalization capability of the traffic prediction model based on Recurrent Neuronal Networks and Long Short-Term Memory (**RNN-LSTM)**. The goal is for errors to decrease and for the validation and training curves to show very similar trends, which validates the reliability of the model.
- **Upper right:** an illustration of how **YOLO** detects objects in real time and tracks them using the **Deep SORT** algorithm.
- **Lower right:** comparisons are shown between predicted values and actual values in 5-minute intervals.

LabVAT integrates a set of technologies into a modular and scalable ecosystem:

- **Computer Vision Engine:**

    - Deep neural networks (YOLO-v5, Deep SORT, CNN) to detect, classify, and track vehicles in real time.
    - Complementary algorithms: centroid calculation, speed, distance traveled, and generation of virtual geofences.
- **Traffic Prediction Model (RNN – LSTM):**
    - Anticipates congestion based on historical and real-time data.
    - Average prediction error: ±3 vehicles per 5-minute interval.
- **Trip Assignment Model (Simulated Annealing – SA):**
    - Optimizes truck departures to reduce waiting times at terminals.
    - Has achieved a reduction of up to 5.97 hours in accumulated waiting times, compared to 18.95 hours in non-optimized scenarios, based on an experimental case with 14 vehicles scheduled within a 24-hour window at a loading/unloading terminal.
- **Mobile Application (Android, React Native):**
    - Sends real-time geolocation data in the background.
    - Detects entry into virtual geofences with **100% accuracy** in tests.
- **Software modules:**
    - Real-time communication.
    - Scalable infrastructure.
    - Dynamic dashboard for traffic monitoring, vehicle positioning, recommendations, and video processing.

Key Results
The LabVAT algorithms and technologies have been validated in different environments and independently. The mobile application was tested with at least five cargo vehicles, successfully recording complete routes of over two hours, in collaboration with a trucking company.

In addition, the detection, classification, and traffic flow analysis algorithms were evaluated using real-time cameras provided by Mexico's Secretariat of Tourism. The optimization and trip assignment algorithm was also tested with real-time positioning data from the same private company.

Although the results are based on controlled tests and simulations under real-world conditions, they demonstrate the robustness and applicability of the methodology.

Computer Vision Engine
Functionality of the system was capable of:
- Detection, classification, and tracking of vehicles in three categories (small, medium, large).
- Implementation of innovative segmentation techniques (Parzen FDP) to estimate congestion on road segments.
- Development of data persistence mechanisms with memory management for real-time operation.

Prediction and Assignment
- Robust traffic predictions with LSTM networks at three levels of fluidity.

- SA algorithm reduced waiting times from **18.95 hours (worst case)** to **5.97 hours on average**, reaching as low as **4.95 hours** in some scenarios.
- Assignment error reduction of **16.63%** after 10 iterations.

Mobile App and Virtual Geofences

- Field tests with **100% accuracy in arrival detection**.
- Stable real-time communication with the central platform.

Key Benefits

- **For intermodal terminals:** Reduced waiting times and efficient itinerary scheduling.
- **For carriers:** Lower operating costs and more predictable travel times.
- **For citizens:** Reduced congestion and emissions in urban areas.
- **For the transport sector:** Scalable platform adaptable to other logistics nodes (ports, airports, borders).

Glossary

- **Yolo**. A state-of-the-art, real-time object detection algorithm that processes an entire image with a single neural network. YOLO divides the image into a grid and simultaneously predicts bounding boxes and class probabilities, making it one of the fastest and most efficient object detection methods.
- **Deep Sort**. An object tracking algorithm that extends SORT by integrating deep appearance features. It improves robustness in multi-object tracking by combining motion information (Kalman filter, Hungarian algorithm) with visual descriptors extracted by a deep neural network, enabling accurate and continuous tracking of objects across video frames.
- **CNN.** A type of deep learning neural network specifically designed for processing structured grid data such as images. CNNs use convolutional layers to automatically learn spatial hierarchies of features, making them highly effective for tasks like image classification, object detection, and recognition across video frames.

Future Vision

LabVAT aims to consolidate itself as a **Mexican intelligent monitoring network** in Mexico's main highways and intermodal terminals.

With its scalability in hardware and software, and support from domestic and international organizations, LabVAT is projected as a strategic tool to:

- Modernize transport management.
- Reduce negative traffic impacts.
- Strengthen the logistics competitiveness of Mexico and the Asia-Pacific region.

Appendix II Laboratory of Computer Vision and Intelligent Transportation Systems (LabVAT) Methodology

Literature Review

Introduction

The rapid growth of urban populations and the increase in motor vehicle use have made traffic congestion a significant issue. Inefficiencies in transportation lead to economic losses, higher levels of pollutant emissions, and a decline in citizens' quality of life. In response to these challenges, Intelligent Transportation Systems (ITS) are emerging as a promising solution. These systems utilize the convergence of information technology, communication, and artificial intelligence to optimize vehicle flow.

In the exploration of new, minimally invasive ways to reduce traffic generated by commerce and logistics, multiple recent investigations have explored the potential of artificial intelligence (AI) and emerging technologies, such as blockchain, artificial neural networks, and advanced digitalization. These tools have been evaluated for their ability to optimize vehicle flow, reduce waiting times, and improve real-time decision-making, especially in urban areas and loading/unloading zones.

Vehicle congestion is a global problem with serious economic and environmental implications. This literature review examines the use of AI and intelligent transportation systems (ITS) as strategies to mitigate this phenomenon. This document analyzes the evolution and paradigms of AI in ITS, delving into key strategies like traffic prediction and forecasting, adaptive traffic light control, dynamic route guidance, and the coordination of connected and autonomous vehicles (CAVs). The potential of solutions based on computer vision, deep learning, and the IoT is particularly notable. The current challenges are also discussed, such as validating models in real environments, data privacy, and infrastructure barriers and their costs. Finally, directions for future research towards resilient and ethically responsible transportation systems are proposed.

This literature review aims to synthesize and analyze the most recent and effective strategies based on AI and machine learning for reducing traffic. The focus of this study is on high-impact publications from recent years to provide an updated state of the art. The document structure begins with the conceptual foundations in **Section 1**, followed by a short summary of the most significant references in the context in **Section 2**, key strategies found in the bibliography in **Section 3**, a comparative analysis of the key strategies is presented in **Section 4**, a discussion and future work is presented in **Section 5**, and finally, conclusions and bibliography in **Sections 6 and 7**, respectively.

Section 1. Conceptual Foundations: AI in Intelligent Transportation Systems

The evolution of artificial intelligence (AI) in Intelligent Transportation Systems (ITS) has been driven by advancements in computational power and the availability of data. In the past, transportation systems relied on deterministic models with fixed rules. However, the rise of big data has facilitated the creation of adaptive, predictive, and real-time transportation systems. A recent study reviews AI-enabled applications in these systems, emphasizing their contributions to route optimization and congestion management, see the Transportation Engineering journal article "AI-enabled applications towards intelligent transportation" (Iyer, 2021).

Main data resources used.

Intelligent transportation systems rely on the massive collection of data. The primary sources include:

- Data from IoT and telematics sensors: Data from sensors installed on roads, traffic lights, and vehicles to monitor vehicle flow, speed, and density in real-time. The concept of "Highway 4.0" proposes the digitalization of roads to improve safety with IoT sensors and AI (R. Singh et al., 2021). An improved transportation model also integrates IoT and AI algorithms for more efficient management (Al-Ani et al., 2023).

- Data from Computer Vision Systems: Traffic cameras that capture images and videos processed by deep learning algorithms for vehicle detection and classification (Alnfiai, 2022). This technology is key for accurately estimating traffic flow, as this technique allows obtaining the number of vehicles, their classification and speed at high pressures (Saputri et al., 2024).
- Connected and Autonomous Vehicles (CAVs) data: Information from vehicles that communicate with each other (V2V) and with infrastructure (V2I), provide a dynamic overview of traffic conditions. AI powers these communication systems for seamless management (Lv et al., 2021).
- Mobile and GPS data: Information from mobile devices can be used to track movement patterns and traffic flows in large urban areas.

Technological strategies.

The main AI paradigms applied in traffic management include:

- Deep Learning: Networks like Convolutional Neural Networks (CNN) are ideal for processing images and videos (Anitha et al., 2024). One study proposed the fusion of visual features to estimate visibility on foggy highways using deep learning networks (Yang et al., 2023). Furthermore, UAVs combined with AI have been used for congestion recognition (Jian et al., 2019).
- Reinforcement Learning: This paradigm allows agents, such as traffic light controllers, to learn to make optimal decisions in dynamic environments (Mathiane et al., 2023).
- Optimization Algorithms: Algorithms like the Lightning Search Algorithm are used in combination with deep transfer learning for vehicle classification (Alnfiai, 2022). Hybrid systems also combine neural networks and genetic algorithms to optimize cooperative transportation planning (Borodin et al., 2021).

Section 2. Short Summaries of relevant articles

This section presents summaries that clearly synthesize the research objectives and methodologies, providing an overview of the available bibliography.

Al-Ani, A. K. et al. (2023). This article proposes an improved transportation model that integrates the Internet of Things (IoT) and artificial intelligence (AI) algorithms. The objective is to optimize transportation management, resulting in reduced congestion and increased efficiency. The model seeks to improve overall vehicle flow through the integration of technologies.

Alnfiai, M. M. (2022). This study presents an AI solution that uses the Lightning Search Algorithm in combination with Deep Transfer Learning for vehicle classification. This methodology is useful for traffic analysis and management as it allows for the identification and categorization of different types of vehicles.

Anitha, C. et al. (2024). This document describes an AI-powered congestion-free transportation system, whose effectiveness is demonstrated through extensive simulations. The system proposes solutions for public transportation that seek to reduce congestion and improve urban mobility.

Bharadiya, J. P. (2023). This article is a critical review that explores the various applications of artificial intelligence in transportation systems. It provides an overview of the state of the art in this field and the key challenges.

Borodin, A. et al. (2021). The research focuses on hybrid intelligent systems for cooperative transportation planning. The proposed model combines neural networks and genetic algorithms to optimize routes and fleet management, improving the transportation system's efficiency.

Bakheet, S. & Al-Hamadi, A. (2022). The authors present a deep neural network framework for real-time detection of vehicular accidents. The system uses temporal motion templates from video data to quickly identify collisions and alert authorities.

Calatayud, A., Katz, R., & Riobó, A. (2022). This Inter-American Development Bank document analyzes the digital transformation of transportation in Latin America and the Caribbean. It discusses the challenges and opportunities in implementing emerging technologies in the region.

Jian, L. et al. (2019). This article explores the combination of Unmanned Aerial Vehicles (UAVs) with AI technology to recognize traffic congestion. The approach uses an aerial perspective to monitor congested roads and detect incidents.

Lv, Z. et al. (2021). This study reviews how communication systems for ITS are empowered by AI. It emphasizes how coordination between vehicles (V2V) and between vehicles and infrastructure (V2I) allows for more efficient traffic management.

Iyer, L. S. (2021). This article reviews AI-enabled applications in intelligent transportation systems. It describes how AI contributes to route optimization, congestion management, and improved road safety.

Mathiane, M. J. et al. (2023). This document describes a traffic light control system that uses a two-dimensional Convolutional Neural Network (2D-CNN). The system estimates vehicle density at an intersection and adaptively adjusts light timings to optimize vehicle flow.

Moreno, M. et al. (2023). The authors propose VARVO, a novel method that uses only video data for the rapid detection of vehicle crash events. The objective is to improve emergency response and reduce road downtime.

Saputri, H. A. et al. (2024). This study focuses on the implementation of the YOLO v7 algorithm to estimate traffic flow in the city of Malang. The methodology is based on object recognition to provide accurate data on vehicle density.

Singh, P. et al. (2022). The article analyzes the convergence of blockchain and AI technology and their applications in transportation systems. The combination seeks to improve security, efficiency, and transparency in transportation management, including congestion reduction.

Singh, R. et al. (2021). This work introduces the concept of "Highway 4.0," which involves the digitalization of roads to improve road safety. IoT sensors and machine learning are used to protect vulnerable road users.

Pástor, K. E. S. et al. (2023). This study highlights the importance of integrating emerging technologies, including AI, in industrial design for more efficient transportation and logistics management.

Flórez, N., & López, E. (2023). This document is a literature review on the evolution of last-mile logistics. It discusses the need for innovative technologies to improve delivery efficiency in urban environments and reduce associated traffic.

Sánchez Chumpitaz, D. S. et al. (2024). The article explores the impact of artificial intelligence on logistical competitiveness, using the Chancay megaport in Peru as a case study. It analyzes how AI can optimize port efficiency, which in turn affects terrestrial transportation flow.

Yang, W. et al. (2023). This study develops a system for estimating visibility on foggy highways using a deep learning network. The system fuses multiple visual features to help ITS manage traffic in adverse weather conditions.

Tamayo Contreras, P. et al. (2024). This work focuses on the "lead time" in the supply chain for the Asia-Mexico maritime route. Although it does not focus on AI, its analysis is relevant for identifying logistics bottlenecks that AI solutions could mitigate.

Section 3. Main Strategies Detected in the Bibliography

The most significant AI-based strategies for vehicle flow optimization can be classified as follows:

a. Traffic State Prediction and Forecasting

Accurate traffic prediction is fundamental for proactive management. A study implemented the YOLO v7 algorithm for vehicle flow estimation in the city of Malang, which provides crucial data for decision-making (Saputri et al., 2024). These models can forecast congestion, allowing authorities to take preventive measures, such as adjusting traffic lights or disseminating alternative routes. The use of deep neural networks has also been applied for real-time vehicular accident detection, which helps reduce road downtime (Bakheet & Al-Hamadi, 2022). Similarly, the VARVO method uses only video data for rapid crash detection, improving emergency response (Moreno et al., 2023).

b. Adaptive Traffic Signal Control

Traditionally, traffic lights operate with fixed cycles, which do not adapt to variations in demand. AI enables the development of adaptive control systems that optimize light timings in real-time. A proposed system uses a two-dimensional Convolutional Neural Network (2D-CNN) to estimate vehicle density at an intersection and adjust the signals accordingly (Mathiane et al., 2023. This type of system, assisted by computer vision, seeks to solve urban congestion.

c. Dynamic Route Guidance and Demand Management

AI can guide drivers through more efficient routes, reducing congestion. A study explored the use of unmanned aerial vehicles (UAVs) and AI to recognize traffic congestion, which could facilitate dynamic guidance (Jian et al., 2019). Furthermore, hybrid intelligent systems that combine neural networks and genetic algorithms are used for cooperative transportation planning, optimizing the routes of an entire fleet (Borodin et al., 2021). An improved transportation model integrates IoT and AI algorithms for more efficient management and a reduction in congestion (Al-Ani et al., 2023).

d. Coordination of Connected and Autonomous Vehicles (CAVs)

Connected and autonomous vehicles are considered the next frontier in traffic reduction. A literature review highlights the role of AI in communication systems for ITS, emphasizing how coordination between vehicles (V2V) and infrastructure (V2I) will allow for seamless traffic management (Lv et al., 2021). The ability of CAVs to communicate could eliminate the "wave effects" of congestion, improving vehicle flow. AI also facilitates the digitalization of roads ("Highway 4.0"), which improves safety for all road users (R. Singh et al., 2021).

The following table provides an overview of the most significant technological, methodological, and artificial intelligence strategies in the context of the study and the available bibliography.

Strategy	Description	References
Traffic State Prediction and Forecasting	Use of the deep learning algorithm YOLO v7 to recognize vehicles and estimate traffic density in real-time.	"Saputri, H. A. et al. (2024)."
Traffic State Prediction and Forecasting	Use of a deep learning network that fuses multiple visual features to predict visibility, helping ITS manage traffic in adverse conditions.	"Yang, W. et al. (2023)."
Traffic State Prediction and Forecasting	A system that uses a two-dimensional Convolutional Neural Network (2D-CNN) to estimate vehicle density at an intersection and adaptively adjust traffic light timings.	"Mathiane, M. J. et al. (2023)."
Traffic State Prediction and Forecasting	Development of deep neural network frameworks for accident detection from video data, improving response speed. The VARVO method uses only video for crash detection.	"Bakheet, S. & Al-Hamadi, A. (2022); Moreno, M. et al. (2023)."

Strategy	Description	References
Dynamic Route Guidance and Demand Management	Use of hybrid intelligent systems that combine neural networks and genetic algorithms to optimize route planning and fleet management.	"Borodin, A. et al. (2021)."
Traffic State Prediction and Forecasting	Combination of UAVs with AI to obtain an aerial view and recognize traffic congestion, facilitating monitoring and decision-making.	"Jian, L. et al. (2019)."
Dynamic Route Guidance and Demand Management	Development of AI-powered systems that use simulations to demonstrate their effectiveness in reducing congestion and improving mobility, especially in public transportation.	"Anitha, C. et al. (2024)."
Adaptive Traffic Signal Control	Proposal of a model that integrates the Internet of Things (IoT) and AI algorithms for more efficient transportation management.	"Al-Ani, A. K. et al. (2023)."
Coordination of Connected and Autonomous Vehicles (CAVs)	Implementation of IoT sensors and machine learning on roads to improve the safety of vulnerable users, which contributes to a safer and more efficient vehicle flow.	"Singh, R. et al. (2021)."
Dynamic Route Guidance and Demand Management	Application of AI in industrial design for efficient transportation and logistics management. This includes optimizing last-mile logistics.	"Pástor, K. E. S. et al. (2023); Flórez, N. & López, E. (2023)."
Dynamic Route Guidance and Demand Management	Joint use of blockchain and AI in transportation systems to improve the security, efficiency, and transparency of operations, which has an indirect impact on congestion reduction.	"Singh, P. et al. (2022)."
Dynamic Route Guidance and Demand Management	The use of AI to improve efficiency and competitiveness in logistical hubs like megahubs, which affects terrestrial transportation flow.	"Sánchez Chumpitaz, D. S. et al. (2024)."

Section 4. Comparative Analysis.

Most of the reviewed studies employ literature review methodologies and simulation-based approaches to evaluate the potential of artificial intelligence (AI) in transportation systems. For example, studies by (Iyer, 2021) and (Pástor et al., 2023) rely on comprehensive bibliographic reviews to compile and analyze the current state of the transportation and logistics industry. Similarly, (Flórez & López, 2023a) used statistical and trend analysis of publications in the Web of Science database to trace the evolution of last-mile logistics.

Other studies adopt a more technical and experimental approach, focusing on the implementation and evaluation of specific algorithms. (Mathiane et al., 2023) and (Saputri et al., 2024) used simulation tools like Pygame and YOLOv7, respectively, to test their traffic light control and vehicle flow estimation systems. (Borodin et al., 2021) proposed a hybrid intelligent system for cooperative transportation planning. Likewise, the study by (Al-Ani et al., 2023) combined a route management technique with an AI algorithm for data transmission to central servers, validating its effectiveness through the simulation of four scenarios. In contrast, (Alnfiai, 2022) focused on a deep transfer learning approach for vehicle classification. The study by (Singh et al., 2021) proposed an intelligent system architecture without presenting an implementation methodology or concrete results.

A subset of research is oriented towards case studies and comparative analysis. A notable example is the work of (Sebastián et al., 2024), which used a mixed methodology, combining qualitative analysis (expert interviews) and quantitative analysis (data from international organizations) to compare the impact of AI on logistical competitiveness between the People's Republic of China and Latin America, using the Chancay Port megaproject as a focal point. Similarly, (Porfirio et al., 2024) conducted a case study on the Asia–Mexico maritime route, using average and Pearson correlation analysis to evaluate the impact of lead time technology.

An important aspect of traffic management is the adoption of non-intrusive strategies that monitor and control vehicle flow without the need to modify physical infrastructure or directly interact with road users significantly. These solutions typically focus on remote sensors, computer vision, and data analysis, enabling the adaptive and real-time management of the transportation network (Mathiane et al., 2023; Jian et al., 2019). The use of deep learning and computer vision for vehicle flow estimation using a custom dataset including car images and CCTV footage of Malang traffic, and incident detection based on estimated car speeds from video data alone are clear examples of this approach (Moreno et al., 2023; Saputri et al., 2024).

Addressing urban congestion is crucial, but we must also consider the impact of traffic in loading and unloading zones, including ports, intermodal terminals, and distribution centers. Congestion at these critical hubs directly impacts supply chain efficiency, resulting in increased waiting times and higher operational costs (Flórez & López, 2023b). Implementing artificial intelligence and machine learning in these settings is essential for optimizing logistics operations and enhancing competitiveness. For instance, analyzing AI's impact on the logistical competitiveness of megahubs, which serve as vital connectors in global trade, can provide valuable insights (Sebastián et al., 2024).

The results of the studies consistently demonstrate the significant benefits of AI and related technologies in transportation optimization. In traffic control, deep learning algorithms, particularly neural networks, have shown high accuracy in traffic classification and prediction, which optimizes intrusion identification and route planning (León et al., 2022). A concrete example is the neural network model of (Lv et al., 2021), which predicted vehicle passage time with an error of less than 10%. (Mathiane et al., 2023) demonstrated that their traffic light control system, based on convolutional neural networks, achieved a vehicle passage rate of 90% and a vehicle classification accuracy of 96%.

In congestion and logistics management, AI has proven effective for route optimization and cost reduction. For example, the model proposed by (Al-Ani et al., 2023) achieved an average traffic reduction of 97% under real-time conditions. The use of the YOLOv7 algorithm allowed for real-time vehicle flow estimation with an average accuracy exceeding 61% (Saputri et al., 2024). At the logistical level, the application of AI has shown significant potential to reduce transit time and costs, as seen in the reduction of travel times on the Asia-Mexico maritime route after the implementation of lead time technology (Porfirio et al., 2024). (P. Singh et al., 2022) also identified significant advantages by converging blockchain and AI technologies, creating a distributed platform to share data and improve decision-making.

In the area of road safety, AI models have shown exceptional performance in accident detection and prediction. The deep neural network framework developed by (Bakheet & Al-Hamadi, 2022) achieved an accident detection rate of 98.5% with a false alarm rate of 4.2%. The study by (Moreno et al., 2023) presented an algorithm for detecting traffic accidents from video data, improving classification accuracy by applying an oversampling algorithm. The article by (R. Singh et al., 2021) also highlighted the potential of deep learning and vision nodes to predict accidents and monitor infrastructure.

Despite the promising results, the studies identify several areas of opportunity and limitations. The main recurring limitation is the need for more extensive and higher-quality data. (Alnfiai, 2022) noted that their model, while satisfactory in tests, was not validated in real conditions. Similarly, (Bakheet & Al-Hamadi, 2022) and (Saputri et al., 2024) highlighted the need for larger and more varied datasets, especially for the detection of cargo vehicles and accident prediction in more complex scenarios.

Another significant limitation is the lack of infrastructure and supporting policies. Several studies agree that the adoption of AI technologies in transportation is limited by scarce digital infrastructure and a lack of specialized talent (Iyer, 2021; Sebastián et al., 2024). The Inter-American Development Bank (IDB) also highlights the need for more proactive public policies, tax incentives, and public-private collaboration platforms to drive digital transformation in Latin America (Calatayud et al., 2022). In addition, some studies, such as (Iyer, 2021), point out that the lack of standardization and concern for cybersecurity and data privacy are significant barriers to widespread implementation. Further research is needed on how to guarantee system interoperability and the protection of sensitive information (P. Singh et al., 2022).

Finally, most studies focus on the concept or simulation, and not on the actual implementation of the technology, as recognized by (R. Singh et al., 2021) in their study on the digitalization of highways. The generalization of results is a limitation in conceptual studies or those based on secondary data (Iyer, 2021).

Section 5. Discussion: Challenges, Gaps, Open Questions and Future Research.

Despite the advances, the large-scale implementation of these solutions faces several challenges.

- **Validation in real environments**: Many models, especially those based on extensive simulations, have not been tested in real-world environments, raising doubts about their effectiveness and reliability.
- **Privacy and ethics**: The massive collection of data from sensors and cameras raises serious concerns about citizen privacy. Future research must focus on methods that protect personal information while maintaining system effectiveness.
- **Infrastructure and costs**: The implementation of intelligent infrastructure (e.g., adaptive traffic lights, road sensors) requires a significant initial investment, which can be a barrier for many cities. The digital transformation of transportation in Latin America and the Caribbean, for example, highlights these challenges.
- **Cybersecurity**: The dependence on interconnected systems makes them vulnerable to cyberattacks. The convergence of technologies like blockchain and AI could offer solutions to these problems, improving security and transparency.

Future research should focus on addressing the identified gaps and challenges. Some key areas include:

- **Hybrid and holistic systems**: Develop models that integrate multiple data sources (computer vision, IoT, GPS) and AI paradigms for more comprehensive and accurate traffic management.
- **Ethical and privacy models**: Investigate AI algorithms that can work with anonymized or federated data to protect user privacy.
- **Real-world validation**: Conduct pilot projects and case studies that validate the performance of AI models in real cities, instead of relying solely on simulations.
- **Integration of human behavior**: Develop models that incorporate psychological and sociological factors to more accurately predict drivers' responses to intelligent systems.

Section 6. Conclusions

AI and machine learning are transforming Intelligent Transportation Systems, offering innovative solutions for congestion reduction. From real-time incident detection to traffic light optimization, technological advances demonstrate enormous potential. However, the transition from theory to practice requires overcoming significant challenges related to validation, infrastructure, and ethical considerations. The future of research in this field lies in the development of integrated, resilient, and human-centered systems that enable the creation of more efficient and sustainable cities.

AI is a driver of efficiency and safety: The application of AI in traffic and logistics management has shown a remarkable ability to optimize operations, reduce congestion, and improve road safety. The reviewed studies show substantial improvements in traffic prediction, vehicle classification, and accident detection, with accuracies exceeding 90% in some cases (Bakheet & Al-Hamadi, 2022). This positions AI not only as a tool of convenience but as a critical technology for urban safety and sustainability.

AI requires a solid data and infrastructure foundation: Despite the promising results, the effectiveness of AI systems largely depends on the quality and quantity of training data. The lack of broad and representative datasets is a recurring limitation that prevents the generalization of models to real-world scenarios (Saputri et al., 2024). This underscores the need for investment in monitoring infrastructure and the creation of robust databases to maximize AI's potential.

An adoption gap exists between regions: The research reveals a clear disparity in AI implementation between developed economies and regions like Latin America. While there is awareness of the importance of digitalization, the lack of investment in infrastructure, specialized talent, and supporting public policies hinders large-scale adoption (Calatayud et al., 2022; Sánchez et al., 2024). The Chancay Port megaproject in Peru, analyzed by (Sánchez et al., 2024), is an example of how strategic investment can serve as a catalyst for digital transformation in the region.

More real-world implementation studies are needed: Most articles focus on theoretical reviews and simulations, leaving a gap in the validation of models under real conditions. This constitutes a crucial area of opportunity for future research, which should focus on practical implementation, measuring its real impact, and mitigating challenges like cybersecurity, data privacy, and ethical considerations (Iyer, 2021).

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Appendix III. Workshop Agenda

Research and Workshop on Strategies and Best Practices to Reduce Road Traffic Related to Trade in APEC Economies Using Technology and Artificial Intelligence

📍 *Location: Hotel Plaza Camelinas. Av. 5 de Febrero 28, La Capilla, 76170 Santiago de Querétaro, Qro., Mexico*
📅 *Dates: November 19th to 21st, 2025*

Overview

The 3-day APEC Workshop will serve as a vital platform for experts, policymakers, and private sector representatives from APEC economies to explore and evaluate innovative approaches for mitigating traffic in road systems adjacent to maritime ports and related to trade. Through a dynamic blend of research presentations and panel discussions, this event aims to gather actionable feedback, identify cross-sector challenges, and inspire collaboration among the public, private, and academic sectors to integrate traditional practices with cutting-edge digital and AI-driven solutions in a harmonious manner.

Objectives

- **Critically review** non-automated, automated techniques, and methodologies for traffic reduction in and around maritime ports.
- **Showcase the current state and potential** of digital technologies and AI tools to reduce vehicular congestion in freight-related corridors.
- **Discussion on governance and cooperation models** to address challenges in public-private partnerships (PPP) aimed at reducing traffic congestion at port facility entrances.
- **Highlight the urgency and value** of digitalization in transportation systems as a transformative tool for logistics optimization in the APEC region.

Key Themes

- **Innovations**
  – Manual scheduling coordination, time-window systems, physical queuing infrastructure, traffic flow engineering, and zoning strategies.
- **Technologies and Artificial Intelligence**
  – Use cases of AI in dynamic routing, congestion prediction, vehicle assignment, port slot booking systems, and sensor-driven feedback loops.
- **Public-Private Sector Cooperation Mechanisms**
  – Institutional frameworks, stakeholder alignment strategies, and examples of regulatory, contractual, and operational coordination.
- **Digitalization in the Transportation Sector**
  – e-platforms for port-call coordination, real-time dashboards, and government support programs to accelerate port and hinterland integration.

AGENDA

DAY 1: Understanding the Challenge & Learning from Experience

09:30 – 10:00 Registration & Welcome Coffee

10:00 – 10:20 Opening Remarks

Dr Alberto Mendoza | Mexican Institute of Transportation

SESSION 1: Overview of Approaches and Methodologies for Traffic Reduction.

This session will provide a comprehensive overview of existing techniques and methodologies designed to reduce traffic congestion at logistics facility entrances. Participants will have the opportunity to engage in discussions, sharing their valuable insights and experiences related to this topic. All attendees will be encouraged to consider and propose interventions that could be effectively implemented in their specific contexts to enhance traffic management.

10:20 – 11:20

Keynote 1: Mr Ricardo Montoya | Autonomous University of Querétaro

Non-automated strategies for efficient vehicular flow management.

Keynote 2: Ms. Bertha Martínez | CETYS Universidad + Mexican Logistics & Supply Chain Association (AML)

Predictive and Digital Technologies to Alleviate Congestion in Maritime Port Logistics: Strategic Frameworks across APEC Economies.

Q & A Session

11:20 – 11:40 Coffee Break

SESSION 2: Overview of Technologies and Artificial Intelligence for Traffic Reduction.

This session will provide an overview of the current advancements in artificial intelligence technologies designed to alleviate traffic congestion at logistics facility entrances. Participants will be invited to share their insights and perform interventions within this framework.

11:40 – 13:00

Keynote 3: Mr Jorge Barnett | Georgia Tech Panama Logistics Innovation & Research Center

Synchronizing Panama: Seamless Flow at the Bi-Oceanic Intermodal Hub.

Keynote 4: Mr Raúl Suárez | Kale Info Solutions

Digital Corridors and Logistic Hubs.

Keynote 5: Mr William Javier Rojas Moreno | Cargo Director

El Dorado" Airport: Digital Flightpath Toward Competitiveness.

Q & A Session

13:00 – 14:30 Networking Lunch

SESSION 3: Assessment of potential areas for enhancement, challenges, and obstacles.

During this session, four discussion teams will be tasked with identifying methodologies, practices, and techniques that can be enhanced through automation using technology and Artificial Intelligence.

14:30 – 16:10

Teamwork 1-Four (4) teams will be set. Each team will be guided by an expert moderator, who will also compile and synthesize the insights generated by the team members.

Exposition 1-The experts deliver a comprehensive presentation of their findings, outlining non-automated techniques, practices, and methodologies for reducing traffic in logistics facilities.

16:10 – 16:25 DAY 1 Summary

End of Day 1 ---

DAY 2: Digital & AI-Powered Solutions

09:30 – 10:00 Registration & Welcome Coffee

SESSION 4: Mechanisms for Cooperation Between the Public and Private Sectors: Challenges and Opportunities.

This session will focus on mechanisms for fostering collaboration between the public, academic, and private sectors. Participants will be encouraged to share their expertise and engage in discussions during this session.

10:00 – 11:00

Keynote 6: Mr Juan Marcos Mancilla | Port Authority of Valparaíso

The Port of Valparaiso: Collaboration as the Foundation of Its Model.

Keynote 7: Mr Juan Carlos Villa | Texas A&M Transportation Institute

Multiagency Cooperation for the implementation of technology at the United States–Mexico Border.

Q & A Session

11:00 – 11:20 Coffee Break

SESSION 5: Importance of Digitalization in the Transportation Sector.

During this session, information will be shared on the impact of digitalization on the transportation sector, with a focus on road traffic. Participants will be encouraged to share their knowledge and experiences.

11:20 – 12:40

Keynote 8: Mr Juan José Erazo | Just in Flow, S.A. de C.V.

Mr Miguel Barousse | IDEAL, S.A. de C.V.

AI-Powered Smart Corridor: Present Innovations and Future Horizons for the North Bypass Tollway of Greater Mexico City.

Keynote 9: Ms. Asha Sharma | Independent Consultant

Trigger-Driven Digital Traffic Orchestration: Harnessing Real-Time Signals for Predictive Mobility Management.

Q & A Session

12:40 – 13:00

Attendees' survey 1

In this activity, participants will receive a link to complete a survey designed to gather their insights on the importance of digitalization within the transportation sector and traffic management. This survey aims to identify both opportunities for improvement and potential challenges in these fields. Their feedback will contribute to a deeper understanding of the current landscape and future direction.

13:00 – 14:30 Networking Lunch

SESSION 6: Overview of best practices, methodologies, and technologies utilized by APEC economies.

During this session, four discussion teams will be tasked with identifying methodologies, practices, and techniques that can be enhanced through automation using technology and Artificial Intelligence.

14:30 – 16:10

Teamwork 2-Four (4) teams will be set. Each team will be guided by an expert moderator, who will also compile and synthesize the insights generated by the team members.

Exposition 2-The experts deliver a comprehensive presentation of their findings, outlining the techniques, practices, and methodologies that can be effectively automated, along with the relevant technologies and Artificial Intelligence models utilized. They also provide a thorough analysis of the obstacles and challenges encountered during the process.

16:10 – 16:25 **DAY 2 Summary**

End of Day 2 ---

DAY 3: Governance & Collaboration Models

09:30 – 10:00 **Registration & Welcome Coffee**

SESSION 7: IMT - LabVAT: A dedicated research facility specializing in technology and artificial intelligence to mitigate traffic congestion.

In this session, the strategy for developing and operating the Computer Vision and Intelligent Transportation Systems Laboratory (LabVAT) will be outlined.

10:00 – 11:10

Keynote 10: Mr Rodrigo Ramos | National Autonomous University of Mexico

Computer Vision to Optimize Customs Operations.

Keynote 11: Mr Alejandro Ascencio | Mexican Institute of Transportation

Integrating Artificial Vision with Intelligent Transportation Systems: The LabVAT Methodological Framework for Mitigating Congestion in Loading and Unloading Zones.

Q & A Session

11:10 – 11:30

Attendees' survey 2

In this activity, participants will receive a link to a survey designed to collect their insights for enhancing the LabVAT strategy and its implementation actions.

11:30 – 12:00 **Coffee Break**

12:00 – 13:00

Discussion Panel

During this session, the invited experts will discuss the outcomes of sessions and share their insights on (i) the recommendations for APEC member economies, as well as (ii) the implementation actions and resource requirements essential for executing these recommendations effectively.

SESSION 8: Summary Event & Final Remarks.

In this session, a presentation of the event's conclusions and final reflections will be provided.

13:00 – 13:20 DAY 3 Summary & Workshop Final Remarks

13:20 – 14:50 Networking Lunch

END OF THE APEC WORKSHOP

Event Staff:

- José Alejandro Ascencio Laguna – Project Overseer
- Juan Carlos Villa – Consultant and Event Coordinator
- Carlos Daniel Martner Peyrelongue – Researcher and Event Co-Chair
- Alma Rosa Zamora Domínguez – Event Support Staff and Researcher
- Agustín Bustos Rosales – Event Support Staff and Researcher
- Carlos Mario Pérez González – Event Support Staff and Researcher
- Eduardo Montes Herrera – Event Support Staff and Researcher
- Gabriela Cruz González – Event Support Staff and Researcher

Appendix IV. List of Workshop Participants

ID	Name	Economy	Institution	Position in the Institution	Role
1	Juan Marcos Mancilla Medina	Chile	Empresa Portuaria Valparaíso	Logistic Director	Keynote Speaker / Moderator
2	Raúl Suárez	Colombia	Kale Info Solutions	IT Manager LATAM	Keynote Speaker / Moderator
3	William Javier Rojas Moreno	Colombia	El Dorado Airport- Opain	Cargo Director	Keynote Speaker / Moderator
4	Asha Sharma	India	Self-employed	Principal	Keynote Speaker / Moderator
5	Agustín Bustos Rosales	Mexico	Mexican Institute of Transportation (IMT)	Researcher	Participant / Staff Member
6	Alberto Mendoza Díaz	Mexico	Mexican Institute of Transportation (IMT)	Director	Director General of the hosting organization
7	Alma Rosa Zamora Dominguez	Mexico	Mexican Institute of Transportation (IMT)	Researcher	Participant / Staff Member
8	Bertha Martínez Cisneros	Mexico	CETYS Universidad	Researcher	Keynote Speaker / Moderator
9	Carlos Daniel Martner Peyrelongue	Mexico	Mexican Institute of Transportation (IMT)	Coordinator of the Integrated Transport and Logistics Department	Coordinator of the hosting organization
10	Carlos Mario Pérez González	Mexico	Mexican Institute of Transportation (IMT)	Researcher	Participant / Staff Member
11	Eduardo Montes Herrera	Mexico	Mexican Institute of Transportation (IMT)	Researcher	Participant / Staff Member
12	Gabriela Cruz González	Mexico	Mexican Institute of Transportation (IMT)	Researcher	Participant / Staff Member
13	José Alejandro Ascencio Laguna	Mexico	Mexican Institute of Transportation (IMT)	Head of the Intelligent Transportation Systems Unit	Keynote Speaker / Project Overseer
14	José Antonio Anguiano Breña	Mexico	State Infrastructure Commission of Querétaro	Infrastructure Sub coordinator	Special guest

ID	Name	Economy	Institution	Position in the Institution	Role
15	Juan José Erazo	Mexico	Just in Flow Ecosystems (consultant at IDEAL Infrastructure for the Development of Latin America)	CEO	Keynote Speaker / Moderator
16	Miguel Barousse	Mexico	IDEAL	Roadway Operations Subdirector	Keynote Speaker / Moderator
17	Ricardo Montoya Zamora	Mexico	Autonomous University of Querétaro	Researcher	Keynote Speaker / Moderator
18	Rodrigo Ramos Díaz	Mexico	UNAM-FI	Professor assistant	Keynote Speaker / Moderator
19	Jorge E. Barnett Lawton	Panama	Georgia Tech Panama Logistics Innovation & Research Center	Managing Director	Keynote Speaker / Moderator
20	Chris Pilara	Thailand	Port Authority of Thailand: Laem Chabang Port	Public Private Partnership Project Management	Participant
21	Darapan Sribhen	Thailand	Port Authority of Thailand	Director, IT Plan and Standard Division	Participant
22	Carson Poe	United States	U.S. Department of Transportation, Office of the Secretary, Office of International Transportation and Trade	Senior Transportation Industry Analyst	Participant
23	Juan Carlos Villa	United States	Texas A&M Transportation Institute	Researcher	Keynote Speaker / Moderator /Consultant
24	Minh Dang Ngo	Viet Nam	Ministry of Construction of Viet Nam	Official	Participant

Appendix V Survey I. Importance of Digitalization in the Transportation Sector

Below are the questions and responses to Survey 1:

Institution

Name	Institution
Bertha Martinez Cisneros	CETYS Universidad /AML
Darapan Sribhen	Port Authority of Thailand
Chris Pilara	Port authority of Thailand
Carson Poe	USDOT
Juan Marcos Mancillas	Empresa Portuaria Valparaíso
Raul Suarez	Kale Info Solutions
Rodrigo Ramos	UNAM-FI-LAPI
Juan José Erazo	Just in Flow Exosystems
Willian Javier Rojas Moreno	AEROPUERTO EL DORADO .- OPAIN
Miguel Barousse	IDEAL
Asha Sharma	Independent Consultant
Jorge Barnett Lawton	Georgia Tech Panama Logistics Innovation and Research Center

Economy

Name	Economy
Bertha Martinez Cisneros	Mexico
Darapan Sribhen	Thailand
Chris Pilara	Thailand
Carson Poe	United States
Juan Marcos Mancillas	Chile
Raul Suarez	Tech
Rodrigo Ramos	Mexico
Juan José Erazo	Mexico
Willian Javier Rojas Moreno	Colombia
Miguel Barousse	Mexico
Asha Sharma	India
Jorge Barnett Lawton	Panama

What is your current role or affiliation within the transport, logistics, or technology sector?

Name	What is your current role or affiliation within the transport, logistics, or technology sector?
Bertha Martinez Cisneros	I am currently the Coordinator of the International Logistics Program at CETYS Universidad (Mexico), where I lead academic programs and collaborate with industry on topics related to transport, logistics, supply chain strategy, and emerging technologies.
Darapan Sribhen	IT Strategic planning
Chris Pilara	I am a Business R&D Officer at Laem Chabang Port (Port Authority of Thailand), working in port planning, PPP concession development, and data analytics for transport and logistics.
Carson Poe	Government

Juan Marcos Mancillas	I am Chief Logistic Officer at Puerto Valparaíso
Raul Suarez	Technology
Rodrigo Ramos	Research and education
Juan José Erazo	TI, ITS, IoT and AI consultant
Willian Javier Rojas Moreno	Airport concessionary
Miguel Barousse	I consider the digitalization of processes to be of vital importance for the efficient use of information and for supporting operational procedures, thereby improving the service provided to infrastructure users.
Asha Sharma	Engineering consulting, problem-solving, design for Airports and Roadway Traffic system s
Jorge Barnett Lawton	Researcher (Director of research center)

In your opinion, why is digitalization important for the transportation sector today?

Name	In your opinion, why is digitalization important for the transportation sector today?
Bertha Martinez Cisneros	nan
Darapan Sribhen	It becomes more than just a tool - a driver for efficiency and facilitation.
Chris Pilara	Because data is important. We need data to see the flow of goods and of trucks and to see the actual routing from point a to point b in order to understand where the problem is especially for congestion and without data or digitalization we cannot fix that problem or place important nodes such as truck parking in order to solve the traffic issues with in a port per say.
Carson Poe	The sheer volume of activity makes data-based decision-making at scale nearly impossible without digitalization.
Juan Marcos Mancillas	Because it allows for the optimization of processes, improves people's lives, and generates an overall benefit for the logistics and transportation industry
Raul Suarez	It’s very important for efficiency and accuracy of the information and avoid re processing of data an error margin
Rodrigo Ramos	For both security and trade facilitation
Juan José Erazo	To Generate Dynamic Data Collection, predictions and prevention strategies
Willian Javier Rojas Moreno	Is the current need for taking advantage of the available technologies, data, tools, applications that can improve transportation service levels, efficiency, security/safety and sustainability.
Miguel Barousse	I believe that digitalization in the transportation sector is important because it helps address congestion issues, making operations more efficient while reducing

	operating costs as well as greenhouse gas emissions.
Asha Sharma	1) Because it is available and possible. 2) It will ease the access to information in timely manner 3) can use the data to make informed decisions.
Jorge Barnett Lawton	First, authorities need to have good data to plan infrastructure, so digital tools are a way of achieving that. Second, it helps leverage collective data for better decision making and gaining efficiencies in processes. Third, it's part of the new economy and there's a need to remain competitive under the demands of global clients.

What are the main sources of traffic congestion related to trade in your economy (e.g., seaports, intermodal terminals, highways, border crossings)?

Name	What are the main sources of traffic congestion related to trade in your economy (e.g., seaports, intermodal terminals, highways, border crossings)?
Bertha Martinez Cisneros	Digitalization is vital to today's transportation sector because it strengthens the resilience, efficiency, and competitiveness of supply chains. Real-time tracking, IoT sensors, AI-driven planning, and digital documentation allow companies to anticipate disruptions, optimize routes, reduce empty kilometers, and improve safety. It also enhances transparency for customers, accelerates border processes, and reduces emissions by enabling smarter asset use. As global logistics grow more complex and time-sensitive, digitalization is the foundation that allows transport systems to operate with greater agility, reliability, and sustainability.
Darapan Sribhen	Incomplete data sharing and system integration of Stakeholders
Chris Pilara	Infrastructural readiness and communication between all the parties the terminal the port authority as well as the manufacturers or factories and warehouses. Because trucks come when they want but not when they are supposed to
Carson Poe	Highways: too much volume (freight + non-freight) without reliable, efficient, affordable alternatives
Juan Marcos Mancillas	seaport, highways and border crossing
Raul Suarez	In my opinion it's intercommunication between public and private entities
Rodrigo Ramos	Seaports and customs
Juan José Erazo	Bottlenecks at seaports, at border Ports of Entry, and across the congestion points for cities, logistics hubs, etc.

Willian Javier Rojas Moreno	Market behavior, export perishables is 65% of the cargo arriving at the airport, so cargo generators would be the source.
Miguel Barousse	I would think that one of the longest delays occurs once the goods are transported by road, mainly due to the condition of the highways, police-related disruptions, and the time spent at toll plazas.
Asha Sharma	Often it's a road accident or broken-down vehicle blocking a lane and preventing free flow.
Jorge Barnett Lawton	Seaports are the biggest generator, as there's less flows related to manufacturing. Also, seaports are located very close to urban areas. In general, the convergence of significant population and unplanned areas that evolved into logistics, creates congestion, especially at peak urban mobility times (rush hour).

What digital tools or technologies do you consider most transformative in transportation?

Name	What digital tools or technologies do you consider most transformative in transportation?
Bertha Martinez Cisneros	Internet of Things (IoT)
Darapan Sribhen	Internet of Things (IoT)
Chris Pilara	Artificial intelligence (AI)
Carson Poe	Big Data
Juan Marcos Mancillas	Internet of Things (IoT)
Raul Suarez	Internet of Things (IoT)
Rodrigo Ramos	Internet of Things (IoT)
Juan José Erazo	Artificial intelligence (AI)
Willian Javier Rojas Moreno	Telematics
Miguel Barousse	Internet of Things (IoT)
Asha Sharma	Subject Matter Expertise, thoughtful use of technology, coding
Jorge Barnett Lawton	All of them. I want to say IoT and Telematics are enablers for Big Data and AI, so those come first.

What has been your experience with implementing digital solutions in transport operations?

Name	What has been your experience with implementing digital solutions in transport operations?
Bertha Martinez Cisneros	My experience with digital solutions in transport operations combines academic expertise with hands-on collaboration with industry. I have worked with logistics and manufacturing companies to evaluate and implement digital platforms such as transportation management systems (TMS), route optimization tools, IoT-based visibility systems, and analytics dashboards for demand

	forecasting and capacity planning. These solutions have helped improve service reliability, reduce empty kilometers, strengthen cross-border coordination, and support data-driven decision-making. Additionally, I integrate these tools into my academic programs to ensure students are trained in the technologies shaping modern logistics.
Darapan Sribhen	PCS
Chris Pilara	Still very tough in Thailand
Carson Poe	nan
Juan Marcos Mancillas	I implemented a Port Community System in Puerto Valparaíso throughput levels.
Raul Suarez	Personally, I develop software for freight forwarders and now a days I am collaborating in the implementation of the ACCS for El Dorado Airport in Bogota Colombia
Rodrigo Ramos	Research only
Juan José Erazo	Digital transformation with IA to enhance the operation and maintenance activities
Willian Javier Rojas Moreno	Good results looking to reduce waiting time at the cargo terminal using Truck Slot Management.
Miguel Barousse	My experience has been in the highway sector, where I have participated in the implementation of ITS systems, Electronic Toll Collection, and now in the design of an operational model that we call 'On-Route Operation.
Asha Sharma	Digitalization of a single project at a smaller scale to see how it works. What's required to develop it and how it performs has been a welcome step towards digitalization in general.
Jorge Barnett Lawton	There's a lot of resistance to change on all fronts. For larger companies it's not resistance to digital solutions but rather protecting their data (you need a solid use case). For smaller companies, it's about digital adoption and them sometimes not being comfortable with technology. With government it's about lack of continuity of programs. In general, it's difficult because transport systems involve a lot of fragmented land actors, which have higher levels of resistance and lower level of technology adoption.

How has digitalization affected decision-making or logistics planning in your economy?

Name	How has digitalization affected decision-making or logistics planning in your economy?
Bertha Martinez Cisneros	Digitalization has significantly improved decision-making in Mexico by providing

	greater visibility of operations, real-time tracking, and better data for forecasting. Companies can now plan routes, manage inventories, and coordinate cross-border operations with more precision and speed.
Darapan Sribhen	Hopefully, it will reduce the logistic cost.
Chris Pilara	None becuase it's currently non existent
Carson Poe	Digitalization is inseparable from decision-making
Juan Marcos Mancillas	Is necessary, because it increase the performance of the Logistic processes. Improving the security of the port's zones. Also reduce the time operation and for this is a sustainability profit.
Raul Suarez	That makes trouble in the traffic and a lot of wasted time waiting until the cargo can be loaded/unloaded
Rodrigo Ramos	Faster passenger flow thanks to codes and scanners, reduced response time on highways, bottleneck reduction thanks to predictive maintenance, and increased security thanks to CCTV and x-ray inspection.
Juan José Erazo	Positive impact. Improve predictive prevention
Willian Javier Rojas Moreno	It becomes a tool to change from reactive to predictable.
Miguel Barousse	I believe that in Mexico, digitalization is only just beginning, with different levels of progress across various sectors such as highways, customs, railways, airports, ports, and transfer stations. However, the progress achieved so far has delivered very positive results.
Asha Sharma	With airports, Dashboards have been useful tool in providing necessary overview for decision-making.
Jorge Barnett Lawton	It has helped in terms of ITS applications in the main metro area for the purpose of handling streetlights and traffic flows. But we still lack a lot of capabilities on the public side, like V2I capabilities for emergency management or things that are standard in systems worldwide for many years. In terms of planning, digital tools and data collection has helped informed infrastructure decisions on the maritime and land side to some extent, much less in terms of air. Digitalization has reduced a lot of paper processes, but mainly in the bigger government agencies (example Customs or Panama Canal) but smaller agencies for which logistics and urban mobility is not a priority (ministry of agriculture that handles inspections) digitalization has not progressed, so a lot of

	processes still have portions that are paper or manual, impeding from extracting all the benefits.

How would you describe the current level of digitalization in your economy's transport and logistics sector?

Name	How would you describe the current level of digitalization in your economy's transport and logistics sector?
Bertha Martinez Cisneros	Emerging
Darapan Sribhen	Moderately advanced
Chris Pilara	Not digitalized
Carson Poe	Moderately advanced
Juan Marcos Mancillas	Moderately advanced
Raul Suarez	Emerging
Rodrigo Ramos	Emerging
Juan José Erazo	Moderately advanced
Willian Javier Rojas Moreno	Emerging
Miguel Barousse	Emerging
Asha Sharma	Moderately advanced
Jorge Barnett Lawton	Moderately advanced

Which digital tools or technologies are currently used in your economy to monitor or manage freight-related traffic? (e.g., sensors, GPS tracking, AI forecasting, video analytics, digital platforms, etc.)

Name	Which digital tools or technologies are currently used in your economy to monitor or manage freight-related traffic? (e.g., sensors, GPS tracking, AI forecasting, video analytics, digital platforms, etc.)
Bertha Martinez Cisneros	Mexico uses GPS tracking, IoT sensors, digital freight platforms, and AI-based forecasting tools to monitor and manage freight-related traffic. Video analytics, electronic toll systems, and digital customs platforms also play a significant role in improving visibility and operational control.
Darapan Sribhen	All of above
Chris Pilara	Non
Carson Poe	Sensors, GPS tracking, AI, video, ITS, phone notifications, phone apps, camera, RFID, Bluetooth, hours of service trackers (GPS?)
Juan Marcos Mancillas	Sensor, GPS tracking, TAGs, Video Analytics, Predictive system, unified windows,
Raul Suarez	GPS, Sensors, Plate/Face Recognition
Rodrigo Ramos	GPS tracking, video analytics, digital twins
Juan José Erazo	Sensors, GPS, AI forecasting, Video Analytics, Machine Learning, Predictive Modelling, etc.
Willian Javier Rojas Moreno	GPS tracking and emerging video analytics
Miguel Barousse	I believe that, to a greater or lesser extent, for example, organized road freight transport is almost entirely equipped with GPS tracking. Highway Control Centers use video analytics

	through digital platforms, and the use of AI is now beginning to be incorporated.
Asha Sharma	LUX uses several proprietary tools created for management of daily operations. Specific tools not known to me.
Jorge Barnett Lawton	RFID and tags for truck monitoring has medium advance, with plans to improve over the next year. Toll highway systems are medium to advanced. However, AI forecasting and video analytics have not been adopted openly beyond research/pilots. So basically, tools are being used to monitor and manage operations, but the data from operations is not being fully leveraged for advanced applications.

How prepared is your institution or economy to integrate AI-powered tools (e.g., predictive analytics, computer vision, digital twins) into traffic management?

Name	How prepared is your institution or economy to integrate AI-powered tools (e.g., predictive analytics, computer vision, digital twins) into traffic management?
Bertha Martinez Cisneros	Preparing but lacking resources
Darapan Sribhen	Preparing but lacking resources
Chris Pilara	Preparing but lacking resources
Carson Poe	Partially prepared
Juan Marcos Mancillas	Partially prepared
Raul Suarez	Fully prepared
Rodrigo Ramos	Fully prepared
Juan José Erazo	Partially prepared
Willian Javier Rojas Moreno	Preparing but lacking resources
Miguel Barousse	Preparing but lacking resources
Asha Sharma	Partially prepared
Jorge Barnett Lawton	Partially prepared

What types of data are most difficult to collect, integrate, or share in your economy's transport and logistics sector?

Name	What types of data are most difficult to collect, integrate, or share in your economy's transport and logistics sector?
Bertha Martinez Cisneros	Queue prediction at terminals or ports
Darapan Sribhen	Queue prediction at terminals or ports
Chris Pilara	Real-time traffic monitoring
Carson Poe	Not necessarily most difficult, but it's been difficult to predict cross-border rail disruptions and the downstream impacts
Juan Marcos Mancillas	Real-time traffic monitoring
Raul Suarez	Customs information
Rodrigo Ramos	Data exchange between private/ gov. and between different gov. agencies.
Juan José Erazo	Incident and risk management
Willian Javier Rojas Moreno	Vehicle flow optimization
Miguel Barousse	Incident and risk management

Asha Sharma	Vehicle flow optimization
Jorge Barnett Lawton	Queue prediction at terminals or ports

What are the main challenges to digital adoption in the transportation sector in your economy?

Name	What are the main challenges to digital adoption in the transportation sector in your economy?
Bertha Martinez Cisneros	Cultural
Darapan Sribhen	Cultural
Chris Pilara	Government side management does not care for this and does not push for this to happen
Carson Poe	Regulatory
Juan Marcos Mancillas	Cultural
Raul Suarez	Cultural
Rodrigo Ramos	Financial in the case of new infrastructure for digitization and cultural in the case of adoption.
Juan José Erazo	Financial
Willian Javier Rojas Moreno	Cultural
Miguel Barousse	Cultural
Asha Sharma	Realizing that there is a need for improvement.
Jorge Barnett Lawton	Cultural

How do you perceive the role of regulation and public policy in either enabling or hindering digital transformation in your economy?

Name	How do you perceive the role of regulation and public policy in either enabling or hindering digital transformation in your economy?
Bertha Martinez Cisneros	Regulation and public policy play a dual role: they can accelerate digital transformation when they provide clear standards and modernized procedures, but they can also slow progress when regulations are outdated or inconsistently applied. In Mexico, advances such as electronic invoicing, digital customs systems, and traceability requirements have enabled modernization, while gaps in interoperability, regulatory clarity, and institutional coordination still limit full adoption.
Darapan Sribhen	Progressive
Chris Pilara	They are important if you really want to implement but now public policy is not there yet to support this advancement and development of these AI and its systems and ecosystem
Carson Poe	Will likely be central
Juan Marcos Mancillas	I think that many times is a complication, because the speed of the regulations are very slow compared with the technology and digital transformation speed.

Raul Suarez	Requires an intensive update in order to fit the actual changes and development
Rodrigo Ramos	Public policy supports research and education but other gov. agencies hinder data exchange and joint decision making.
Juan José Erazo	A highly important
Willian Javier Rojas Moreno	is not moving fast enough reflecting the needs of a more efficient supply chain.
Miguel Barousse	In Mexico, there are no public policies that facilitate digital transformation, and there is a strong tendency toward overregulation.
Asha Sharma	Policies for digitalization in Luxembourg are progressive. What exactly is digitalized in various companies related to transportation systems is confidential though and it's not known outside.
Jorge Barnett Lawton	On one hand, public policy takes time, so if I had to focus on one area, is on establishing a common policy for institutions for digitalization of citizen-facing processes, so that we can start generating data that we can use later. The other thing, data sharing protocols should be established, so institutions share the data they have with others. We sometimes see multiple institutions overlapping doing the same thing.

What trends in transport digitalization do you think will dominate the next 5–10 years?

Name	What trends in transport digitalization do you think will dominate the next 5–10 years?
Bertha Martinez Cisneros	Over the next 5–10 years, transport digitalization will be dominated by AI-driven planning, real-time visibility platforms, autonomous and semi-autonomous systems, digital trade documentation, and sustainability-focused technologies such as smart routing and emissions tracking.
Darapan Sribhen	Big data and Data Driven platform
Chris Pilara	PCs
Carson Poe	Unsure
Juan Marcos Mancillas	Artificial Intelligence, digital twins, Video Analytics
Raul Suarez	IA. Can bring us a better vision of transportation challenges and maybe alternatives to replace the actual ways to move cargo and people
Rodrigo Ramos	IoT, advanced analytics, digital twins, and cybersecurity.
Juan José Erazo	AI and Data driven digitalization
Willian Javier Rojas Moreno	IoT - Digital Twins
Miguel Barousse	The use of artificial intelligence supported by Internet of Things technologies, computer vision, and free-flow tolling systems

Asha Sharma	More than digitalization, it will be standardization of infrastructure. Interoperability will be a theme which means the way data has collected and shared will be uniform or cohesive. I'm unsure that AI will dominate. People may realize that it's understanding of a system and how to solve it is what matters is that an AI isn't assistance, or a tool, but not a full on technology that can solve any problem.
Jorge Barnett Lawton	Real time tracking of assets (trucks, port equipment, even people) with either decentralized devices (IoT) or common data capture (surveillance cameras, traffic cameras, etc., enabled with computer vision). With that a lot of operational needs can probably be satisfied.

In your opinion, what does a "fully digitalized" transportation system look like?

Name	In your opinion, what does a "fully digitalized" transportation system look like?
Bertha Martinez Cisneros	A fully digitalized transportation system is one in which all actors, carriers, shippers, ports, customs, and regulators, operate with real-time data, automated processes, digital documentation, and interoperable platforms. Decisions are predictive rather than reactive, efficiency is maximized, and visibility exists across the entire supply chain.
Darapan Sribhen	Seamless integration between multimode of transportation.
Chris Pilara	A fully digitalized transportation system is one where every actor — ports, terminals, shipping lines, customs, truckers, and logistics companies — connects through interoperable platforms with real-time, reliable, API-driven data exchange. Manual paperwork is eliminated, and all processes such as vessel clearance, cargo release, gate-in/out, billing, and tracking are automated. Physical operations are supported by IoT sensors, digital twins, autonomous vehicles, and predictive decision-support tools. Users and operators benefit from transparency, accuracy, and seamless end-to-end visibility across the entire supply chain.
Carson Poe	No longer needing to crowd source local road distresses or realities, such as potholes or unplowed bike lanes
Juan Marcos Mancillas	Is a System where the human interaction is minimal. Where there are many business roles that determinate the system's behavior
Raul Suarez	Maybe looks like a "Pipe" and the traffic flows inside it fluently

Rodrigo Ramos	Secure and with minimal checkpoints or waiting times.
Juan José Erazo	Real Time analysis capabilities and predictive capacity
Willian Javier Rojas Moreno	An integration platform that solves operational congestions (physical-digital-human) to provide transparently the information even to become a market place of opportunities for all ecosystem-community.
Miguel Barousse	With efficient processes, no congestion at any point in the goods-movement chain, on-time deliveries, real-time knowledge of transport status and location, complete customer satisfaction, a transportation system with a lower carbon footprint, and full transparency across all processes.
Asha Sharma	I believe in even in its current state, transportation is very highly digitalized since early 2000s. Perhaps vehicles of the future will share information such as potential congestion, or an accident ahead.
Jorge Barnett Lawton	One where the moment people start a process, whether it's planning a trip, programming a space at a port, or moving persons or cargo, at all times you're getting real-time updates of the factors that can affect you in origin, journey or destination through digital companionship (in-vehicle guidance, push notifications of evolving conditions, etc.), and where you have little to no interaction with other actors that will stop that journey (i.e., gates, parking facilities, etc.)

What new skills or training do you think transportation professionals need for a digital future?

Name	What new skills or training do you think transportation professionals need for a digital future?
Bertha Martinez Cisneros	For a digital future, transportation professionals must develop skills in data analytics, digital platforms, and automation technologies. They will need to understand AI-driven planning, real-time visibility systems, digital compliance processes, and cybersecurity basics. Equally important are soft skills such as critical thinking, problem-solving, and the ability to collaborate across digital and physical operations. These capabilities will allow professionals to interpret data, optimize transport decisions, and adapt to increasingly complex and technology-driven supply chains.
Darapan Sribhen	Data Analytics

Chris Pilara	Transportation professionals will need a mix of digital skills and operational understanding: data analytics, dashboarding (e.g., Tableau/Power BI), API and PCS fundamentals, and familiarity with AI-assisted decision tools. Cybersecurity awareness, digital documentation (e-BL, e-Gate, e-Payment), and basic automation/IoT knowledge will become essential. Beyond technical skills, professionals must develop stronger problem-solving, stakeholder coordination, and change-management capabilities to lead digital transformation in complex environments such as ports and logistics nodes
Carson Poe	Depends on role. I think some basic primer materials for communities would help--specifically materials that would allay and/or address fears or preconceptions.
Juan Marcos Mancillas	Machine Learning, Data Engineering
Raul Suarez	The understanding in the legal frameworks and the ways that the cargo moves in terms of type of cargo, drivers, police and all the actors in the industry
Rodrigo Ramos	Soft skills and reliable AI assistance.
Juan José Erazo	Math and Statistical Analysis Data Science, Physics High Efficiency Computing
Willian Javier Rojas Moreno	Soft skills to upscale change management to a digital way to operate.
Miguel Barousse	I will refer specifically to transport operators (drivers): they need the ability to handle electronic devices and basic knowledge of the software used in the various platforms, depending on their operational area.
Asha Sharma	Subject matter expertise will be above all else. Nothing can be done without it. So people who actually understand what they do are there will be very important. Coding knowledge and some hands-on training in model development will allow them to see how AI tools actually work. This will allow them to make that decision-making.
Jorge Barnett Lawton	Data analysis is a must. Also, basic capabilities to leverage current AI tools, so at least being able to perform streamlining of heavy work through existing technology.

Appendix VI. Survey II. LabVAT Methodology Survey

Below are the questions and responses to Survey 2

Economy

Name	Economy
Raul Suarez	Mexico
Bertha Martinez Cisneros	Mexico
Chris Pilara	Thailand
Asha Sharma	India
Juan Marcos Mancilla Medina	Chile
Juan Jose Erazo Garcia Cano	Mexico
Carson Poe	United States
Darapan Sribhen	Thailand
Ricardo Montoya Zamora	Mexico
Miguel Barousse	Mexico
Jorge Barnett	Panama
Willian Javier Rojas Moreno	Colombia
Rodrigo Ramos	Panama

Institution

Name	Institution
Raul Suarez	Kale Info Solutions
Bertha Martinez Cisneros	CETYS Universidad
Chris Pilara	Port authority of Thailand
Asha Sharma	Independent Consultant
Juan Marcos Mancilla Medina	Empresa Portuaria Valparaíso
Juan Jose Erazo Garcia Cano	JUST IN FLOW
Carson Poe	USDOT
Darapan Sribhen	Port Authority of Thailand
Ricardo Montoya Zamora	Universidad Autónoma de Querétaro
Miguel Barousse	IDEAL
Jorge Barnett	Georgia Tech Panama Logistics Innovation and Research Center
Willian Javier Rojas Moreno	AEROPUERTO EL DORADO - OPAIN
Rodrigo Ramos	UNAM-FI

Why do you think technology and AI are essential tools for addressing traffic congestion?

Name	Why do you think technology and AI are essential tools for addressing traffic congestion?
Raul Suarez	Because the AI is able to do the things faster and realize multiple calculations and considerations than can help a lot in the data transformation process and use.
Bertha Martinez Cisneros	Por que puede procesar informacion em tiempo real
Chris Pilara	Technology and AI allow cities to move from reactive traffic management to predictive, real-time decision-making. AI can process large volumes of mobility data, identify patterns, optimize traffic signals, and forecast

	congestion before it occurs. These tools help reduce delays, improve safety, support multimodal planning, and make transport systems more efficient overall.
Asha Sharma	Depends on the project. However, as most AI is based on high-quality visual feed intake, systems of equipment or essential
Juan Marcos Mancilla Medina	Because it contributes to the efficiency of the supply chain, and with its advantages it provides certainty in the timing of flows
Juan Jose Erazo Garcia Cano	Because can provide data to calibrate and run stochastic and other kind of models
Carson Poe	A colleague often says, "vehicles are computers with wheels." Tech and AI tools offer an opportunity to unlock, synthesize, and put to good use all of the data they are collecting and generating. Given the magnitude economic, environmental/health losses that traffic congestion creates, all potential solutions should be explored.
Darapan Sribhen	Positioning of the objects on the road is one of the key factors to identify the congestion. Technology is deployed to acquire those data through multiple sources. Then using AI as a tool to predict or identify problems along the route is better than human monitoring.
Ricardo Montoya Zamora	Because problems are more and more complex and this requires advanced solutions. Nowadays there is much information and many variables to analiza so traditional modelos can solve modern problems
Miguel Barousse	"Because of the convergence of different technologies and the ability to analyze data.
Jorge Barnett	Location visibility (through tracking devices, cameras, etc.) provides data that is useful to plan and mitigate congestion, especially during peaks of activity. AI allows processing very quickly the data and generating feasible options for improved decisions, but it does require sufficient high-quality data.
Willian Javier Rojas Moreno	Brings real time information already analyzed to improve decision making under potential scenarios improving response times by having design and proven corrective actions.
Rodrigo Ramos	Humans can't manage big data in real time without automated analysis, algorithms, and AI.

What traffic-related problems should the labVat prioritize?

Name	What traffic-related problems should the labVat prioritize?
Raul Suarez	Traffic JAMs
Bertha Martinez Cisneros	Traffic congestion

Chris Pilara	The lab should prioritize issues that have the greatest impact on everyday mobility, including chronic congestion hotspots, inefficient fixed-time traffic signals, and limited multimodal data integration that slows down public transport coordination. It should also focus on freight and last-mile delivery traffic, which heavily affects urban flow, as well as pedestrian and cyclist safety in mixed-traffic environments. Addressing the lack of high-quality mobility datasets is equally important, as reliable data forms the foundation for any long-term traffic management strategy.
Asha Sharma	How to address ad hoc scenarios. For example, tropical contest to do a truck break down on the roadway, producing the number of length available.
Juan Marcos Mancilla Medina	Congestión in port areas and predict the flows, when a vessel is programed on the port.
Juan Jose Erazo Garcia Cano	Bottleneck predictions for example
Carson Poe	Truck traffic/idling in maritime port and border crossing areas.
Darapan Sribhen	I am not sure. But I think there are more factors to be considered in case of cargo transportation.
Ricardo Montoya Zamora	It has to be aligned to the purpose of it's creation. I think computer visión, prediction in trucks, ports ad airports.
Miguel Barousse	Ports sn toll plazas
Jorge Barnett	I'm biased so I would say ports, but I think it could be meaningful to take advantage of the relationship IMT has with authorities and try to see if something can be done about public transport due to congestion in the city (example, improving the timing of the buses), or maybe last mile delivery in the historical center. The first would involves a lot of vehicles for which the government already has GPS data or has more power to get it (as opposed to cargo vehicles) and the cameras in the city are probably there as well. The second because it can be a very focused area (example a low emissions/low noise zone).
Willian Javier Rojas Moreno	Focus on those main connecting routes that generate (80/20) mixed traffic (vehicles and trucks) helping the urban centers to design better flows and using but also increasing the accuracy by using geofencing at the surroundings of the terminals phasing the arrival as per the turn time at the docks.
Rodrigo Ramos	Road security, port, airport and terrestrial border congestion,

What innovative technologies or methodologies do you think the lab should explore?

Name	What innovative technologies or methodologies do you think the lab should explore?
Raul Suarez	Integration with private and public entities en order to get the data validated and accurate.
Bertha Martinez Cisneros	Last mile
Chris Pilara	I would say digital twin to be able to simulate as well
Asha Sharma	Most of the exploration should be beyond visual technologies. Based on the presentation, ways to compensate to continue monitoring in absence of GPS data
Juan Marcos Mancilla Medina	IA, Video Analitics, use drones in the last mile.
Juan Jose Erazo Garcia Cano	bayesian and neural networws
Carson Poe	
Darapan Sribhen	Perhaps using Big Data as one source.
Ricardo Montoya Zamora	Dron, heatmaps, and IoT
Miguel Barousse	All the areas mentioned—computer vision, the Internet of Things, and maybe topics related to connected vehicles.
Jorge Barnett	It's using good tools that are available, can't think of anything particular.
Willian Javier Rojas Moreno	Create digital tag by matching sensitive / known data which can be used through the truck journey to activate and monitor IATA behavior.
Rodrigo Ramos	Harnessing data from private stakeholders after anonymization and filtering or deployment of its own IoT infrastructure.

How should the laboratory engage with city governments, transport agencies, or the public?

Name	How should the laboratory engage with city governments, transport agencies, or the public?
Raul Suarez	Maybe trying to give them something usefull inside their own operations
Bertha Martinez Cisneros	To generate solutions for urban traffic
Chris Pilara	The laboratory should engage through a collaborative and transparent approach that involves co-designing pilot projects with government and transport agencies to ensure solutions meet real operational needs. It should maintain open communication by publishing dashboards, field results, and performance metrics that the public can easily understand. Hosting workshops and consultations will help gather feedback from communities and stakeholders, while establishing open data standards will encourage collaboration with researchers,

	startups, and private-sector innovators. Engaging logistics operators and public transport agencies is also crucial to ensure that mobility solutions align across all sectors of the urban transport system.
Asha Sharma	1. Obtain data from them. 2 use them as a platform to pilot real-world deployment. The deployment may not engaged with. Real-world decision-making but its performance will give you a very good indication of how well your model performs.
Juan Marcos Mancilla Medina	I think, the most important is to show the benefit to the those stakehoder, and to sure the confidenciality of the data. Maybe with a NDA.
Juan Jose Erazo Garcia Cano	Explore public private partnerships and MOUs for data sharing
Carson Poe	Prepare and give presentations in layperson terms describing the lab's vision, what it's done to date on limited resources, and where it wants to go + what involvement or support is necessary to continue.
Darapan Sribhen	Through pilot project.
Ricardo Montoya Zamora	Foros, sharing their innovations on internet, podcasts and proyects
Miguel Barousse	First, identifying the authority that is key to the problem being addressed, and second, establishing collaboration agreements—and if the actor is a private entity, presenting a cost–benefit proposal.
Jorge Barnett	Should definitely consider identifying a few use cases of the laboratory capabilities and pitch to public transport agencies, cargo generators, transport companies, logistics parks, but each of them with a set of use cases.
Willian Javier Rojas Moreno	From the academic sector thrive to have the best network of current hardware available that can deliver quality information to the system behind the App.
Rodrigo Ramos	In the meanwhile, the public and transport agencies should be interested in sharing anonymized data from their vehicles. City and federal governments should also be interested in sharing information about their concession roads. They only intend to use this data for road security and optimization purposes. They need to promote and spread this objective.

How satisfied are you the session "IMT - LabVAT: A dedicated research facility specializing in technology and artificial intelligence to mitigate traffic congestion"?

Name	How satisfied are you the session "IMT - LabVAT: A dedicated research facility specializing in technology and artificial intelligence to mitigate traffic congestion"?
Raul Suarez	Very Satisfied
Bertha Martinez Cisneros	Very Satisfied
Chris Pilara	Satisfied
Asha Sharma	Satisfied
Juan Marcos Mancilla Medina	Satisfied
Juan Jose Erazo Garcia Cano	Very Satisfied
Carson Poe	Very Satisfied
Darapan Sribhen	Satisfied
Ricardo Montoya Zamora	Very Satisfied
Miguel Barousse	Satisfied
Jorge Barnett	Very Satisfied
Willian Javier Rojas Moreno	Very Satisfied
Rodrigo Ramos	Very Dissatisfied