U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

FREIGHT DIGITAL SOLUTIONS AND EMERGING TECHNOLOGIES

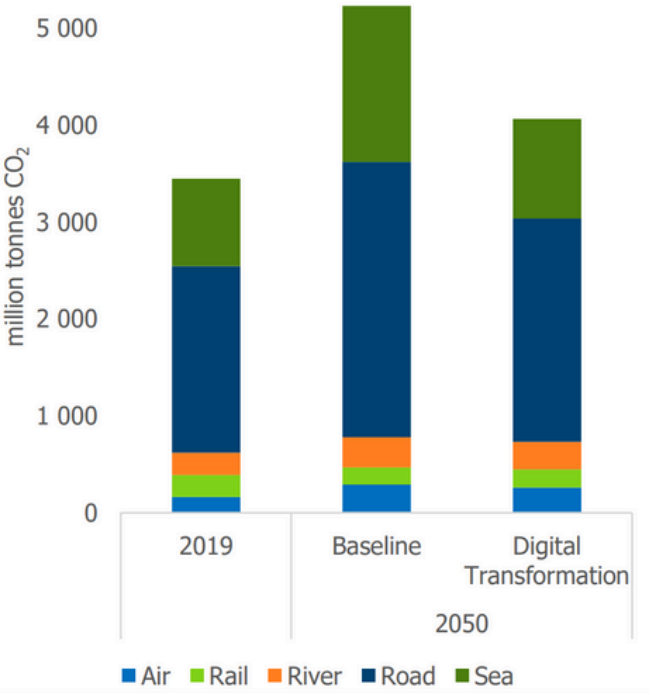
Digital solutions and innovative technologies provide a seamless experience for freight carriers and consumers alike while reducing traffic and emissions associated with deliveries.

Table of Contents

OVERVIEW

Best Suited for:
Long Term & Short Term
Urban, Suburban, Rural & Tribal

Freight digitalization can provide environmental, health, and economic benefits, including **reduced congestion on roadways and in and around ports, lower emissions, and operational and efficiency improvements** for freight carriers (see the Freight Operational Strategies strategy page for more detail). Digital solutions include advanced scheduling and routing systems, location tracking using geographic information systems (GIS), and other intelligent transportation systems (ITS) (see the Intelligent Transportation Systems strategy page for more detail). The International Transport Forum analyzed the overall impacts of a 'Digital Transformation' scenario on freight-related CO_2 emissions and found that implementing a range of digital solutions to the freight sector will result in over 20% lower CO_2 emissions in 2050 compared to the no-action baseline.



The impact of digital transformation on freight-related CO_2 emissions. The total rise in emissions between 2019 and 2050 is limited to only 18%, despite the expected 165% increase in freight transport demand. (Source: ITF, 2022)

Freight industry leaders have strong incentives to reduce unnecessary travel, delays, and other factors that contribute to higher operating costs. **Innovative technologies,** such as truck platooning technology or other connected vehicle technologies, **can improve the efficiency of transportation assets and services, including freight logistics.**

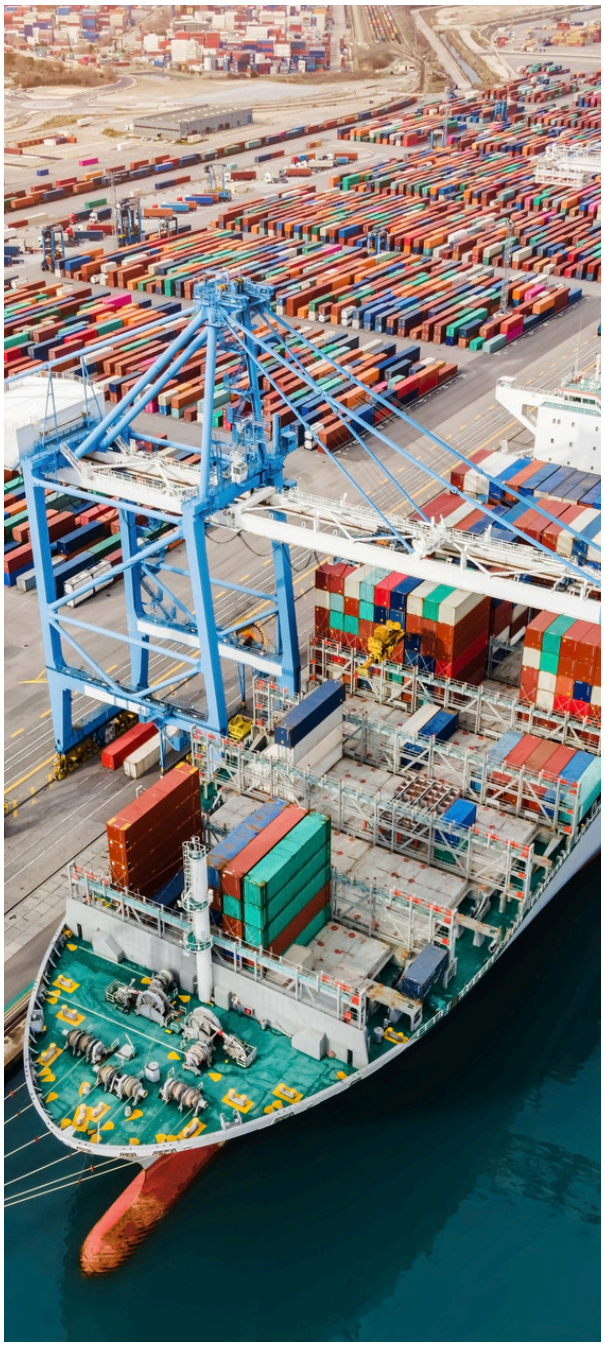
Did you know?

The National Renewable Energy Lab (NREL) has partnered with Google to reduce emissions through more eco-friendly mapping in Google maps. Eco-routing solutions have been shown to reduce fuel consumption and emissions by 10-20% or more (NREL, 2021).

JUMP TO: Overview | GHG Reduction Potential | Co-Benefits | Cost Considerations | Funding Opportunities | Complementary Strategies | Case Studies | What to Read Next | Resources

Real-time data can allow transportation systems to operate more efficiently and respond to changes and unexpected delays more effectively. For example, optimizing truck deliveries to ports through improved scheduling, automated gate systems, and other strategies can reduce emissions from trucks idling while waiting to unload their cargo. Micromobility devices such as electric cargo bikes have increasingly become integrated into goods movement and are typically managed using apps and location-based services. Truck signal priority can be used at intersections with high levels of truck traffic to extend the green time and allow more trucks to make it through a signal cycle. Giving trucks extra green time can improve safety by reducing the likelihood that a truck will run a red light and cause a crash. It can also reduce delays and congestion caused by the longer acceleration times that trucks need to reach posted speed limits.

Curb Management:
Managing the curb is an increasingly important task that can contribute to VMT reductions from freight in both urban and downtown rural core contexts. Curb management options, such as parking spot reservation systems and off-peak deliveries, can be implemented using phone apps and GIS location tracking. Delivery lockers can also reduce curb congestion and respond to an increase in demand for deliveries. Firms can use delivery lockers to consolidate shipments for multiple households, reducing delivery costs and trips. At the same time, customers can pick up their package at their convenience at a secure location close to their home. Both companies and consumers can manage delivery lockers using apps and automated systems.



JUMP TO: Overview | GHG Reduction Potential | Co-Benefits | Cost Considerations
Funding Opportunities | Complementary Strategies | Case Studies | What to Read Next | Resources

Examples of freight digitalization technologies include:

- Apps that freight carriers, businesses, and consumers can use to manage goods movement and deliveries.
- Advanced truck routing systems (dynamic re-routing or eco-routing).
- Electronic delivery lockers.
- Micromobility deliveries, including e-cargo bikes and robots.
- Drone deliveries.
- Ports technologies.
  - Multi-modal scheduling systems.
  - Truck appointment systems.
  - Just-in-time queuing.
  - Automatic gates.
- Vehicle-to-everything (V2X) deployments for freight.
  - Connected vehicle technologies.
    - V2X-enabled vehicles using dedicated 5.9 GHz spectrum.
  - Signalized intersections.

GHG REDUCTION POTENTIAL

This section provides an overview of GHG emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

VEHICLE-TO-EVERYTHING (V2X) TECHNOLOGIES AND FREIGHT-RELATED EMISSIONS

Frequent acceleration/deceleration, excessive speeds, slow movements on congested roads, and unnecessary idling contribute to increased fuel consumption and emissions.

Eco-driving strategies, early warning systems, and other **vehicle-to-vehicle and vehicle-to-infrastructure technologies (V2V/V2I) systems** can reduce CO_2 emissions. For example, hazard alert systems installed in trucks and passenger cars can reduce CO_2 emissions by around 5% for vehicular densities up to 3000 vehicles/hour (Outay et al., 2019).

Advanced truck routing systems can reduce VMT and emissions. In one study with a medium-sized logistics company, application of an advanced scheduling and routing system to urban deliveries resulted in a 27% reduction in CO_2 emissions and the same number of orders being delivered with 8.6% less routes, 18% less service time, and 21% less kilometers per route (Kechagias et al., 2020).

The **Pittsburgh Smart Loading Zones program** uses a combination of technology to monitor loading zone utilization and notify the parking authority of violations. Pilot program outcomes include substantial reductions in idling time and curb disruptions: decrease in average park duration of 25%, decrease in average double park duration of 40%, and increase in turnover of nearly 25% (Engage Pittsburgh, 2024).

The North Central Texas Council of Governments is working with Freightpriority to deploy **signal prioritization technology** in the Dallas-Fort Worth area. The truck signal priority system uses existing GPS data to provide extra green time as needed at specific intersections. The deployment is expected to improve route efficiency and reduce fuel use and freight truck-related emissions across the region (Freightpriority, 2024).

REDUCING EMPTY TRUCK TRIPS AND IMPROVING LOAD FACTOR

"Full Truckload" (FTL) and "Less-than-Truckload" (LTL) are types of trucking services. FTL is popular with business that move large volumes of stock on a regular basis. One shipping trailer contracts to a single shipper, consignee or customer. The freight shipment (which may or may not utilize the entire trailer) is carried from point A to point B. In LTL shipping, the carrier makes multiple stops to pick up and drop off goods, and the shipment may be loaded and unloaded multiple times. LTL is better suited for occasional, smaller shipments where delivery times can be flexible.

Typical trucks that are not driving empty carry only about 57% of their capacity. “Digital freight brokers” can help consolidate loads from multiple shippers onto a single trailer to improve the loader factor. Pooling shipments can reduce GHG emissions by 15-40% (Nakajima, 2024).

Flock Freight has developed an alternative to LTL called “shared truckloads” (STL). Their technology estimates shipment pricing based on the probability that the shipments can be pooled and creates a shipment plan for a single truck that enables pooling when possible. Flock estimates that their STL solution reduces GHG emissions by 15-40% due to more direct routing and improved load factors (Nakajima, 2024).

Empty truck trips are responsible for a significant share of VMT and emissions. Collaboration among carriers and truck appointment systems (TASs) can help reduce the number of trips between terminals and client locations (Schulte et al., 2017).

CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

SAFETY

Digitalization of freight movements can improve safety outcomes, including decreasing interactions between freight vehicles and vulnerable road users. See the safety benefits of recent ITS deployments here.

- Trucks can be retrofitted with bicyclist/pedestrian detection systems and collision early-warning systems.
- Signal priority for freight vehicles at intersections can reduce frequent accelerations and decelerations and reduce the likelihood of accidents.
- Smart loading zones and curb management systems reduce congestion from delivery vehicles and the need for double parking and parking across bike lanes.

See the Intelligent Transportation Systems strategy page for more detail.

For example, a curb management system in Washington, DC reduced double parking by 64% and immediately improved safety in crosswalks and bike lanes (Pyzyk, 2019).

COST SAVINGS

The use of computer systems for vehicle routing and scheduling, especially in cases where more than 10 vehicles are needed, usually leads to cost reductions of between 10% and 20% for carriers (Drexl, 2012).

Tire manufacturer Michelin designed EFFIFUEL, a freight logistics ecosystem that includes telematics, training in eco-driving techniques, and an optimized tire-management system. The system can lead to an average annual savings of €3,200 ($3,542 USD, 2016) for long-haul trucks, or at least a 2.1% reduction in total cost of ownership for truck fleet operators (WEF, 2016).

The United Parcel Service's (UPS) Package Flow Technology reduces fuel consumption and emissions by optimizing pickup and delivery allocations and by designing delivery routes that minimize total distance covered, driving time, and idling time. The system also uses historical data to forecast conditions and create routes that eliminate left turns to minimize waiting at lights. In 2009, UPS

reported savings of almost $200 per vehicle per day in fuel costs due to a combination of these strategies (UPS, 2009).

ECONOMIC GROWTH

Digital solutions have transformed the freight logistics industry. In a 2016 white paper, the World Economic Forum estimated that digital technology will lead to the creation of 2 million jobs and reduce carbon emissions by 10 million tons. Overall, the total value impact to the logistics industry was estimated to be $1.5 trillion (WEF, 2016).

ACCESSIBILITY AND EQUITY

Communities of color and low-income neighborhoods are particularly disadvantaged with respect to freight-related congestion, noise, and emissions (EPA, 2014). Digital solutions can direct truck shipments along more equitable routes, shift freight traffic from trucks to other modes, and reduce fuel burn and emissions through use of ITS and V2V/V2I technologies. For example, a StreetLight analysis found that truck activity has a disproportionate impact on disadvantaged communities in New York State in terms of travel time delays, with the average truck delays about twice as long per roadway mile in disadvantaged vs. non-disadvantaged census tracts (StreetLight, 2024).

Digital solutions can direct truck shipments along more equitable routes, shift freight traffic from trucks to other modes, and reduce fuel burn and emissions through use of ITS and V2V/V2I technologies.
See the Intelligent Transportation Systems strategy page for more detail.

RURAL COMMUNITIES

Large volumes of freight either originate in rural areas or are transported through rural areas by road, rail, and waterways. Two-thirds of rail freight originates in rural areas, and nearly half of all truck VMT occur on rural roads (USDOT, 2023). Freight digitalization can improve network efficiency and support the selection of less carbon intensive modes to reduce the impacts of freight transport on rural communities.

AIR QUALITY AND HEALTH

Diesel freight is responsible for significant amounts of particulate matter pollution and adverse health effects, particularly in communities living near highways and ports (EPA, 2014). Digital solutions can support eco-routing and optimize freight movements to minimize impacts to local air quality, e.g., by choosing freight transport with less carbon-intensive modes. A study of geofencing-enabled truck routing in Southern California showed a drop in NOx emissions of 74% in disadvantaged communities when trucks used a “least-emissions path” eco-routing option (Jaller et al., 2021).

COST CONSIDERATIONS

The cost to implement freight digitalization systems varies widely depending on the scale, scope, and location of the project.

The ITS Joint Program Office maintains a list of System Cost Updates for V2X Deployments. Freight-related examples include:

- The Colorado Truck Parking Information Management System (TPIMS) has a total estimated capital cost of $9 million.
- An intelligent truck parking management system using cameras to detect parking availability and automatically notify drivers via a website, in-cab messaging, and roadside dynamic message sign costs $70,000 to $120,000.
- The cost to deploy a real-time truck parking information system was estimated at $391,000 per rest area.

See the Intelligent Transportation Systems strategy page for more detail.

FUNDING OPPORTUNITIES

FHWA's **Saving Lives with Connectivity: Accelerating V2X Deployment** grant program will fund projects that advance connected and interoperable vehicle technologies. Connected and interoperable vehicle technologies have the potential to greatly reduce motor vehicle crashes and resultant fatalities, injuries, and property damage.

USDOT's **Complete Streets AI Initiative** is a $15 million multi-phase effort that will fund small business to develop new decision-support tool(s) for state, local, and tribal transportation agencies that focus on Complete Streets.

FHWA's **Advanced Transportation and Innovative Mobility Development (ATTIMD)/Advanced Transportation Technology and Innovation (ATTAIN)** support the deployment, installation, and operation of advanced transportation technologies. Eligible activities under this program that advance transportation system efficiency include implementing technology to integration of transportation service payment systems and implanting advanced mobility access and on-demand transportation service technologies.

DOE's **Advanced Research Project Agency (ARPA-E)** is funding projects that develop technology to model the low-carbon intermodal freight transportation system of the future. The projects are expected to reduce emissions by enabling prioritization of low-carbon energy infrastructure deployment, along with data required for the effective deployment of this optimized distribution system.

USDOT's **Strengthening Mobility and Revolutionizing Transportation (SMART) Grants Program** provides grants to eligible public sector agencies to conduct demonstration projects focused on advanced smart community technologies and systems in order to improve transportation efficiency and safety. Delivery/logistics is included as a technology area for eligible projects.

FHWA's **Exploratory Advanced Research (EAR) Program** is exploring the development of artificial intelligence (AI) and machine learning technology within the surface transportation sector. The EAR program has also funded several computer vision research projects to enhance the safety and efficiency of surface transportation.

USDOT's **Reduction of Truck Emissions at Port Facilities Grant Program** provides funding to reduce truck idling and emissions at ports, including through the advancement of port electrification. The program also includes a study to address how ports and intermodal port transfer facilities would benefit from increased opportunities to reduce emissions at ports, and how emerging technologies and strategies can contribute to reduced emissions from idling trucks.

FHWA's **National Highway Freight Program (NHFP)** is aimed at improving the efficient movement of freight on the National Highway Freight Network (NHFN). The program supports investment in infrastructure and operational improvements that strengthen economic competitiveness, reduce congestion, reduce the cost of freight transportation, improve reliability, and increase productivity.

FHWA's **Accelerated Innovation Deployment Demonstration Program** provides funding to State departments of transportation (DOTs), Federal land management agencies, and Tribal Governments to accelerate the implementation and adoption of proven innovative technologies. Project activities may involve any phase of a highway transportation project from project planning through project delivery.

COMPLEMENTARY STRATEGIES

Digital strategies, including smart phone apps and advanced scheduling and routing systems, support micromobility delivery services. Freight digitalization strategies, such as GPS tracking and eco-routing, streamline dispatch and route optimization, enabling micromobility deliveries to efficiently navigate congested urban areas.

Digital solutions can support intermodal freight logistics through advanced tracking and scheduling systems and optimizing freight movements based on commodity, tonnage, and other factors.

Freight digitalization strategies, such as real-time tracking systems and predictive analytics, allow logistics operators to optimize delivery routes and schedules, identifying opportunities for off-peak delivery based on factors like traffic patterns, delivery windows, and customer preferences. In addition, curb reservation systems, common carrier lockers, and other technological solutions can facilitate deliveries during off-peak hours.

Parking reform strategies, such as smart parking, curb management strategies, and other on- and off-street parking solutions for freight deliveries, rely on freight digitalization technology to reduce congestion and time lost to circling and idling.

View All Strategies

CASE STUDIES

PITTSBURGH SMART LOADING ZONES

The City of Pittsburgh and Pittsburgh Parking Authority have implemented Smart Loading Zones, using Automotus curb management technology, as a way to manage curb space to increase delivery efficiency and decrease congestion and emissions at curbs. License plate sensors are used to analyze curbside activity and automate payment for the duration a vehicle is parked at a curb. The smart zones are expected to decrease emissions from unnecessary idling and circling, reduce parking-related congestion, improve pedestrian and cyclist safety, and increase parking turnover in business districts.

FLYTREX DRONE DELIVERY ZONES

Flytrex, a drone delivery service, is currently operating in Texas and North Carolina. Flytrex flies commercial drones and make deliveries to residential backyards and parks for restaurants and retailers. In 2020, the company partnered with the North Carolina Department of Transportation as part of the FAA's BEYOND program which is working towards drone operation without visual ground monitoring. In North Carolina, Flytrex makes deliveries to neighborhoods in Holly Springs, Durham, and Raeford, with plans to expand to additional areas over the next few years. Users can order food and other items from a list of restaurants and grocery stores on an app. The program has been shown to be safe, energy efficient, and can help reduce traffic from delivery vehicles in neighborhoods.

RAILEX PERISHABLES TRANSPORT

Perishables have traditionally been transported almost exclusively by truck (e.g., in 2014, only 2% of fresh produce shipped with the U.S. used intermodal transport). Railex provides transportation and logistics services for perishable cargo. Railex began using refrigerated boxcars and warehouses with climate controls specific to each produce type, automated temperature and humidity controls in railcars, accelerometers to evaluate in-transit events that could damage cargo, and digital inventory management. With the aid of advanced technology, they report cost savings of 10-20% coast-to-coast relative to long-haul trucking.

NASHVILLE SMART CURB ZONE

In 2021, the City of Nashville, in partnership with Coord (now Pebble), a curb management company, launched a Smart Zone Pilot to better manage curb space in the downtown area. Smart Zones enable commercial drivers to use mobile devices to locate, reserve, and pay for time in available loading zones. The Nashville pilot included 14 Smart Zones and over 21 delivery fleets. Nashville was one of four cities selected for Smart Zone pilot in addition to Aspen, CO, Omaha, NE, and West Palm Beach, FL.

Smart Zones allow drivers to find and book available loading zones using a smartphone app (Source: Hammon, 2021).

IMPLEMENTING FREIGHT DIGITAL SOLUTIONS AND EMERGING TECHNOLOGIES: **WHAT TO READ NEXT**

The Urban Freight Lab, a public-private partnership at the University of Washington, provides several resources on the benefits of freight technologies, including:

- Final 50 Feet Research Program: the final 50 feet journey involves a "delivery driver searching for adequate parking, then transferring items from the delivery truck, navigating a route across traffic and through urban obstacle…, concluding when the intended recipient takes receipt of their parcel." Common Carrier Lockers are one digital solution to the final 50 feet problem.
- Curb Occupancy Toolkit: allows for study of the parking behavior of commercial vehicles along the block face and within commercial vehicle loading zones.

The American Council for an Energy-Efficient Economy's (ACEEE) brief, Leveraging Digital Freight Networks to Reduce Emissions, provides policymakers with information on the potential impact of digital freight networks (DFNs) on freight efficiency and emissions in the U.S. Optimizing the movement of goods through information and communications technology (ICT) will be key in achieving substantial reductions in freight-related GHGs.

- DFNs pool data to match shipments to trucks, which can add capacity, improve efficiency, and lower costs to shippers and carriers. Policy makers and industry can coordinate to maximize the benefits of DFNs.
- Uber Freight estimates that with perfect optimization of the U.S. freight network, achieved in part through the use of DFNs, empty miles could be reduced by up to 64% ((Uber Freight, 2023).

In 2022, the International Transport Forum published How Digitally-driven Operational Improvements Can Reduce Global Freight Emissions. The report presents results from a scenario analysis comparing the impact of different freight digitalization strategies on global CO_2 emissions in 2025, 2030, and 2050. Key strategies include: improving truck utilization, strengthening port capacity, adopting

ITS, and reducing intermodal dwell time.

The Truck Parking Information Management System (TPIMS), established with FHWA grant funding by eight member states of the Mid America Association of State Transportation System, provides real time parking availability to drivers along major freight corridors, so that they may proactively plan their routes and make safer, smarter parking decisions.

RESOURCES

GENERAL RESOURCES

FMSCA SAFESPECT Screening Platform**:** FMSCA recently announced this next generation digital inspection platform for commercial vehicle roadside safety inspections. SAFESPECT will improve the efficiency of inspections and decrease wait and vehicle idling time at inspection stations.

FHWA CARMA Program: This program is leading research on cooperative driving automation (CDA) which would enable communication and cooperation between properly equipped vehicles and infrastructure.

DOE CDA Funding Programs: DOE supports CDA research through funding for New Mobility Systems and through the ARPA-E NEXTCAR Program. CDA technologies have the potential to reduce congestion and increase the safety and efficiency of travel on roadways.

FHWA and BTS Freight Analysis Framework (FAF): The FHWA and BTS database contains freight flow data sourced from a variety of sectors, to support freight analysis and inform decision-making. The database provides a comprehensive summary of current freight trends and can be used to predict future trends.

US DOT Freight Logistics Optimization Works (FLOW): Developed by U.S. DOT, FLOW provides an industry forum combined with an information exchange platform to help address supply chain challenges and enable a resilient and globally competitive 21st century freight network.

TOOLS AND MODELING APPROACHES

See the References section for modeling studies on digital freight and associated climate benefits.

REFERENCES

Cleantech Group. (2021). Smart Cities and Curb Management: Innovating for Success. https://www.cleantech.com/smart-cities-and-curb-management-innovating-for-success/

Drexl, M. (2012). Rich vehicle routing in theory and practice. Logistics Research, 5, 47-63. https://doi.org/10.1007/s12159-012-0080-2

Engage Pittsburgh. (2024). Smart Loading Zones. https://engage.pittsburghpa.gov/smart-loading-zones

Freightpriority EcoDrive. (2024). https://freightpriority.com/

Goodchild, A., & Toy, J. (2018). Delivery by drone: An evaluation of unmanned aerial vehicle technology in reducing CO2 emissions in the delivery service industry. Transportation Research Part D: Transport and Environment, 61, 58-67. https://doi.org/10.1016/j.trd.2017.02.017

Hammon, Mary. (2021). Manage the curb with smart loading zones. American Planning Association. https://www.planning.org/planning/2021/winter/manage-the-curb-with-smart-loading-zones/

International Transport Forum (ITF). (2022). Organization for Economic Co-operation and Development. How Digitally-driven Operational Improvements Can Reduce Global Freight Emissions. https://www.itf-oecd.org/digitally-driven-operational-improvements-freight-emissions-reduction

Jaller, M., Pahwa, A., & Region, P. S. (2021). Cargo Routing and Disadvantaged Communities [supporting datasets] (No. PSR-UCD-19-43). United States. Dept. of Transportation. Office of the Assistant Secretary for Research and Technology. https://rosap.ntl.bts.gov/view/dot/58491

Kechagias, E. P., Gayialis, S. P., Konstantakopoulos, G. D., & Papadopoulos, G. A. (2020). An application of an urban freight transportation system for reduced environmental emissions. Systems, 8(4), 49. https://doi.org/10.3390/systems8040049

Kirschstein, T. (2020). Comparison of energy demands of drone-based and ground-based parcel delivery services. Transportation Research Part D: Transport and Environment, 78, 102209. https://www.sciencedirect.com/journal/transportation-research-part-d-transport-and-environment

Nakajima, C. (2024). Leveraging digital freight networks to reduce emissions. ACEEE. https://www.aceee.org/topic-brief/2024/01/leveraging-digital-freight-networks-reduce-emissions

NREL. (2021). Google Taps NREL Expertise To Incorporate Energy Optimization into Google Maps Route Guidance. https://www.nrel.gov/news/program/2021/google-taps-nrel-expertise-to-incorporate-energy-optimization-into-google-maps-route-guidance.html

Office of Transportation and Air Quality. (2014). Near Roadway Air Pollution and Health: Frequently Asked Questions. FAQ, EPA-420-F-14-044, U.S. Environmental Protection Agency, https://www.epa.gov/sites/default/files/2015-11/documents/420f14044_0.pdf.

Outay, F., Kamoun, F., Kaisser, F., Alterri, D., & Yasar, A. (2019). V2V and V2I communications for traffic safety and CO emission reduction: a performance evaluation. Procedia Computer Science, 151, 353-360. DOI:10.1016/j.procs.2019.04.049

Pyzyk, K. (2019). CurbFlow pilot reduced double parking in DC by 64%. Smart Cities Dive. https://www.smartcitiesdive.com/news/curbflow-pilot-reduced-double-parking-in-dc-by-64/567268/

Schulte, F., Lalla-Ruiz, E., González-Ramírez, R. G., & Voß, S. (2017). Reducing port-related empty truck emissions: a mathematical approach for truck appointments with collaboration. Transportation Research Part E: Logistics and Transportation Review, 105, 195-212. https://doi.org/10.1016/j.tre.2017.03.008

StreetLight. (2024). Investigating how trucks impact social equity with new freight data. https://www.streetlightdata.com/investigating-equity-with-new-truck-data/

Uber Freight. (2023). Uber Freight research shows ⅔ of empty miles can be eliminated—here's how. https://www.uberfreight.com/blog/uber-freight-research-shows-%E2%85%94-of-empty-miles-can-be-eliminated-heres-how/

U.S. Department of Transportation (USDOT). (2023). The Critical Role of Rural Communities in the U.S. Transportation System. https://www.transportation.gov/rural/grant-toolkit/critical-role-rural-communities

United Parcel Service (UPS). (2009). UPS Sustainability Report, 2009. https://about.ups.com/content/dam/upsstories/assets/reporting/2009-UPS-Corporate-Sustainability-Report.pdf

World Economic Forum (WEF). (2016). Digital Transformation of Industries: Logistics Industry, World Economic Forum White Paper. https://www.weforum.org/publications/digital-transformation-of-industries/.

For more information visit the DOT Climate Change Center, https://www.transportation.gov/priorities/climate-and-sustainability/dot-climate-change-center