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COMPARATIVE EVALUATION OF NIGHT AND DAYTIME SMALL-BATCH CARGO DELIVERY SYSTEMS IN URBAN ENVIRONMENT

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The growing demand for fast and efficient urban freight transportation, determined by e-commerce and same-day delivery expectation, has raised concerns about the sustainability and cost-efficiency of current logistic systems. The investigation provides a comparative evaluation of small-batch cargo deliveries during daytime and nighttime in urban environment. The study focuses on analyzing cost structures, delivery times, environmental impacts, and logistic challenges. Using mathematical modeling, route optimization algorithms (e.g., Clarke-Wright savings method), and real-world data from a Ukrainian city, the study highlights the potential of nighttime delivery as an effective alternative to traditional daytime schedules, while addressing its limitations and implications for urban logistic policy and infrastructure planning.

As cities continue to grow and urban populations increase, the strain on last-mile delivery services intensifies. The integration of smart city technologies, such as real-time traffic monitoring and adaptive delivery scheduling, may further enhance the effectiveness of nighttime logistics. These innovations can enable more responsive, eco-conscious delivery systems capable of meeting rising demand without compromising urban sustainability goals.The increasing volume of small-batch deliveries—parcels, food, pharmaceutical goods—has transformed the landscape of urban transportation. Rapid urbanization, combined with growing consumer expectations for same-day or next-day delivery, has put immense pressure on logistic systems, particularly in densely populated cities. Urban freight systems must now

reconcile efficiency with environmental responsibility, congestion management, and quality of life for residents. As a result, logistic companies and municipalities are exploring non-traditional delivery windows, particularly nighttime deliveries, to alleviate peak-hour congestion and enhance service reliability. Urban logistics is facing mounting challenges. Rodrigue and Dablanc (2024) emphasize that traditional daytime deliveries are increasingly unsustainable due to traffic congestion, competition for curb space, and emissions from stop-and-go vehicle operation [1]. They suggest that urban freight must be adapted by leveraging technology and innovative scheduling. In contrast, Cardinal (2025) reports that cities trialing nighttime delivery schemes observed a reduction of up to 18% in delivery time and 25% in fuel consumption due to smoother traffic conditions [2]. Night deliveries can also reduce the number of delivery vehicles on roads during peak hours, leading to better air quality and lower daytime noise.

However, drawbacks persist. Class Ace (2024) highlights challenges such as increased labor costs due to night shift bonuses, security risks for drivers in poorly lit areas, and noise disturbances for residents [3]. On the technological front, the deployment of electric vehicles and autonomous delivery systems promises to mitigate emissions and noise concerns, yet their widespread adoption remains hindered by cost and infrastructure constraints.

The core problem addressed in this study is the inefficiency and congestion associated with daytime small-batch deliveries in urban environments. The main objectives are:

- to compare the cost structures and operational efficiency of nighttime and daytime delivery systems;
- to analyze delivery route optimization potential using mathematical modeling;
- to evaluate the feasibility of implementing night deliveries from environmental, technical, and social perspectives;
- to provide practical recommendations for logistics providers and urban planners.

The study combines analytical modeling, real-world data collection, and algorithmic optimization. Key steps include data collector, mathematical modeling.

Data collector is a regional logistics operator in a mid-sized Ukrainian city providing anonymized operational data on delivery routes, timing, fuel use, and labor costs. Surveys and interviews were also conducted with logistics managers, drivers, and city officials. Mathematical modeling here is the cost comparison models were developed incorporating variables such as fuel, labor, delivery time, vehicle wear, and emissions. The Clarke-Wright savings algorithm was used to optimize route planning based on travel time and distance.

Two scenarios were simulated:

- Daytime Deliveries: Peak-hour operations (08:00–17:00), reflecting typical delivery cycles.
- Nighttime Deliveries: Off-peak operations (22:00–06:00), with minimal congestion and reduced interference from pedestrian traffic.

In the daytime scenario, the average delivery time per route was 5.3 hours, with an average of 28 liters of fuel consumed and 12 delivery stops. Standard labor costs applied, but the time lost in congestion and delays impacted efficiency and increased emissions. In the nighttime scenario, the average route time was reduced to 3.8 hours—28% faster—while fuel consumption dropped to 21 liters (25% less). Although night shifts required an additional 20% labor cost, the overall operational cost was balanced out by savings in fuel, faster route completion, and lower vehicle wear-and-tear

The results clearly demonstrate that the night delivery system, despite its logistical and organizational complexity, significantly reduces travel time, which is critical in modern urban environments. Moreover, fuel consumption decreased due to smoother driving conditions and fewer stops, which also translated into improved environmental outcomes. While daytime deliveries offer operational predictability and easier customer access, they suffer from inefficiencies caused by traffic congestion and longer service times at delivery points. In addition, nighttime delivery contributes to better fleet utilization, as vehicles can be operated during hours that would otherwise be idle. This improves return on investment for logistics companies and supports more balanced use of urban infrastructure. Reduced congestion during night hours also

means less wear on public roads, lowering long-term maintenance costs for municipalities. However, successful implementation of night delivery systems requires strategic coordination among stakeholders, including local authorities, residents, and service providers.

The cost analysis done revealed that although night operations required higher initial investments—particularly in staff training, safety measures, and compliance with noise regulations—the long-term benefits include reduced vehicle degradation, optimized fuel usage, and more reliable delivery schedules. Customer surveys further revealed a growing acceptance of night deliveries, especially among commercial clients, who valued earlier stock replenishment and flexible logistics windows. Nonetheless, challenges remain. Urban regulations regarding nighttime noise, residential delivery restrictions, and safety concerns must be addressed. Technological solutions such as quiet electric delivery vehicles and contactless drop-off systems (e.g., smart lockers) can help mitigate these barriers, but they demand cross-sector collaboration and regulatory support.

Conclusion This comparative assessment of night and day small-batch delivery systems in urban environments underscores the advantages of off-peak logistics strategies. Night deliveries prove more time-efficient, environmentally friendly, and, under the right conditions, cost-effective. However, their broader implementation requires careful consideration of labor policies, infrastructure adaptations, and public acceptance. The policy frameworks must evolve to support pilot programs, incentivize sustainable delivery practices, and foster collaboration between private logistics firms and municipal governments. Only through a coordinated, data-driven approach can urban freight be transformed into a system that meets modern economic demands while respecting environmental and social constraints.

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TRANSFORMATION OF UKRAINE'S LOGISTICS SYSTEM IN WARTIME AND PROSPECTS FOR ITS DEVELOPMENT

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Logistics plays a crucial role in the economy of any country, ensuring the uninterrupted movement of goods, raw materials, and services. During wartime, Ukraine's logistic system faced unprecedented challenges such as infrastructure destruction, port blockades, driver shortages, and disruptions in supply routes. Despite this, Ukrainian businesses and government institutions have managed to adapt to the new reality by developing alternative transportation schemes and employing innovative solutions. This article explores the main problems encountered by Ukraine's logistics system during the Russian- Ukrainian war and outlines possible paths for its recovery and future development.

Since the beginning of the full-scale invasion, thousands of kilometers of highways, railways, bridges, and logistic hubs have been destroyed. According to the Ministry of Infrastructure of Ukraine, in the first months of hostilities, more than 23,000 kilometers of roads were destroyed, and over 300 bridges were damaged. This significantly complicated cargo transportation and increased logistics costs. The