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Post-Pandemic Urban Logistics: Addressing E-Commerce Overload with Vertical Automation in Building Design

Stanislav Markovich

Inventor \ Author of Skyscraper Parcels, Founder and Director Project Solutions Enterprises Ontario Inc., Toronto, Canada.

Abstract

The article describes the post-pandemic growth of e-commerce volumes, identifying a new bottleneck in the last mile within high-rise buildings. Corridors, elevator lobbies, and goods-receiving areas have all been temporarily converted into warehouses, resulting in delays, higher costs, and increased sanitary risks. When elevator throughput is also constrained and online purchase volumes remain high, the existing conventional logistics schemes for transportation prove inadequate in both terms of efficiency and safety. This article attempts to rethink urban logistics by considering the integration of specialized vertical automation within the building's frame as an integral part of its engineering system, alongside water supply and HVAC systems. The concept of Skyscraper Parcels has been created for this purpose; it comprises a dock gear-driven conveyor, a dedicated shaft, modular floor-level lockers, and intelligent elevator control. The scientific novelty of the work lies in the comprehensive combination of a micro-fulfillment cell, a conveyor-locker solution, and contactless authorization algorithms in a patented system compliant with CSA B44 and UL 508A standards. The proposed architectural-engineering scheme is implemented at the stage of monolithic casting, requires no additional structural reinforcement, and easily integrates into existing building management systems via an open API. Key results show that vertical automation reduces a courier's time inside the building by an average of 78%, cuts last-mile costs to 28% of total expenses, eliminates 100% of contact points, and provides developers with an internal rate of return (IRR) of 14.4–42% and a payback period of five to nine years. Scaling the technology in North America and further adapting it for megacities in Asia and the Middle East opens up prospects for the sustainable development of urban logistics. This article will be helpful to developers, architects, logistics engineers, and urban planners.

Keywords: *Vertical Automation; Last-Mile Logistics; E-Commerce; Architectural Integration; Conveyor Lockers; Sustainable Engineering Systems.*

INTRODUCTION

The COVID-19 pandemic accelerated the digital behaviors of urban residents more rapidly than any forecast had predicted. According to UNCTAD, the share of Internet users making online purchases rose from 53% in 2019 to 60% in 2020/21 across a sample of 66 countries, and this level persisted even after lockdowns were lifted [1]. In tandem with demand, the physical flow of parcels surged: in the United States alone, shipment volumes increased by 37% in 2020, reaching 20 billion deliveries—approximately 61 parcels per resident [2].

These macro figures are reflected locally, first and foremost, in buildings. Whereas the last mile previously ended at the curb, it now extends to the elevator lobby, storage room, and even to the apartment door. Peaks in delivery hours cluster couriers at entrances, increase elevator downtime, complicate access control, and turn residential and office complex corridors into temporary storage areas. In high-density cities, where sidewalks and roadways have already exhausted their throughput reserves, it is this internal last mile that constitutes the critical bottleneck: it is not the street but the architecture that generates delays, expenses, and carbon emissions.

Hence, the objective of our study. We set out to rethink logistics not through traffic-transport solutions but through the very structure of buildings. We propose considering a suite of vertical automation—integrated hoist shafts, micro-fulfillment cells, multi-level locker cabinets, and intelligent elevator management as a new layer of engineering systems, comparable to water supply or HVAC. The work focuses on how such logistics infrastructure at the point of consumption reduces couriers' time in the building,

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redistributes freight flows vertically, diminishes street-level handling, and ultimately transforms the post-pandemic e-commerce overload from an urban-environment problem into a challenge addressable by architectural and engineering means.

MATERIALS AND METHODOLOGY

The study is based on the analysis of eight key sources: macro-statistics from UNCTAD on the growth in the share of online purchases in 66 countries [1]; the Parcel and Postal Technology report on a 37% increase in U.S. parcel volumes in 2020 [2]; three issues of the Pitney Bowes Parcel Shipping Index for 2021–2024 [3–5]; field observations of 60–100 daily parcel receipts in residential buildings in New York City [6]; modeling of the impact of social-distancing norms on elevator throughput and courier queues [7]; and laboratory data on SARS-CoV-2 viability on cardboard, plastic, and steel for up to three days [8]. The theoretical foundation comprises studies of changes in consumer digital behavior and stresses on urban infrastructure. UNCTAD metrics [1] indicate a sustained high level of online trade following the end of lockdowns, while Pitney Bowes reports [3–5] predict global shipment growth to reach $225 billion by 2028.

Methodologically, the work joins together several complementary approaches. First, a quantitative trend analysis of macroeconomic data was conducted, examining the dynamics of online purchase shares [1] and U.S. parcel shipment volumes [2, 5], which enabled an assessment of the scale of the post-pandemic surge. Second, field observations of the internal last mile in high-rise residential complexes documented elevator delays and courier accumulations in corridors following the methodology of Ranjbari et al. [6]. Third, modeling was used to study the consequences of social-distancing measures on elevator capacity and courier wait times [7]. Fourth, a review of laboratory tests on viral viability on packaging surfaces [8] allowed incorporation of sanitary risks associated with traditional manual delivery. Finally, to evaluate the proposed Skyscraper Parcels architectural-engineering scheme, a conceptual comparative analysis was conducted, comparing standard elevator cores with integrated conveyor-locker solutions in terms of spatial compatibility, architectural integration, and financial parameters for installation and subscription services, based on the author's business plan data.

RESULTS AND DISCUSSION

Over the five post–COVID years, the global parcel flow increased from 131 billion shipments in 2020 to 161 billion in 2022; at a sustained average rate of 6% per annum, the Pitney Bowes index projects this figure to exceed approximately 225 billion by 2028 [3, 4]. The United States is ahead of this curve: 22.37 billion shipments in 2024, equivalent to 66 parcels per capita and over 61 million per day, with volume continuing to grow faster than operators' revenues [5], as shown in Fig. 1.

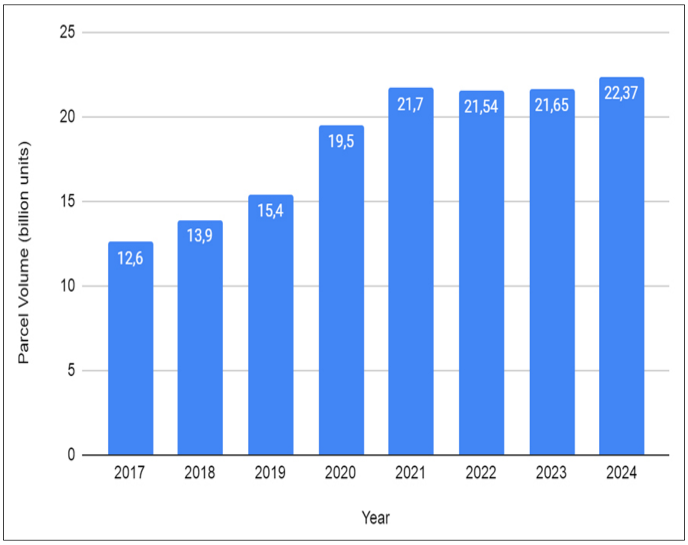

Fig. 1. US parcel volume (in billion) [5]

The impact of this surge is felt at the building level: field observations [6] report that a single residential building in New York already receives 60–100 packages per day, and several city blocks generate up to 600 deliveries daily. Consequently, entry lobbies and elevator foyers have become part of the very logistics chain that once ended at the curb.

These internal zones thus become bottlenecks. Modeling has demonstrated that post-pandemic distancing rules reduced elevator passenger capacity by at least two-thirds, and in some cases by more than 90%, causing queues and forcing couriers to compete with residents for cabin space [7]. Under such conditions, even a brief sequence of deliveries prolongs a courier's time in the building—due to repeated elevator waits and navigation through narrow corridors—and during peak hours, this congestion spills onto the street, compelling delivery vehicles to occupy courtyards and traffic lanes and requiring concierges to manage visitor traffic.

Losses manifest in three dimensions. Economically, a study [6] estimated that circling for parking, repeat delivery attempts, and in-building delays consume up to 28% of total last-mile costs and generate one quarter of its emissions. Temporally, a pilot implementation with shared courier lockers in a 62-storey building in Seattle demonstrated that a centralized vertical node reduces a courier's in-building working time by 78% while simultaneously eliminating failed deliveries. Sanitarily: The high density of contacts in elevators and on floors elevates infection risks. Laboratory tests have shown that SARS-CoV-2 remains viable on cardboard for up to 24 hours and on plastic and steel for up to three days—that is, on typical packaging surfaces and elevator buttons [8]. Thus, the current architecture of high-rise residential buildings has become not merely a parcel bottleneck but an intersection of financial losses, time delays, and epidemiological threats—precisely the systemic strain that demands engineering solutions at the building level rather than at the street level.

The Skyscraper Parcels system treats the receiving dock, vertical conveyor, and floor-level locker as a unified technological flow: the courier scans the barcode, places the load on the receiving dock in the unloading zone, after which the conveyor automatically picks up the container and lifts it within a dedicated shaft—bypassing elevator traffic—directly to modular locker cabinets on the required floor or, in an appropriate configuration, to an individual in-apartment cell, as shown in Fig. 2.

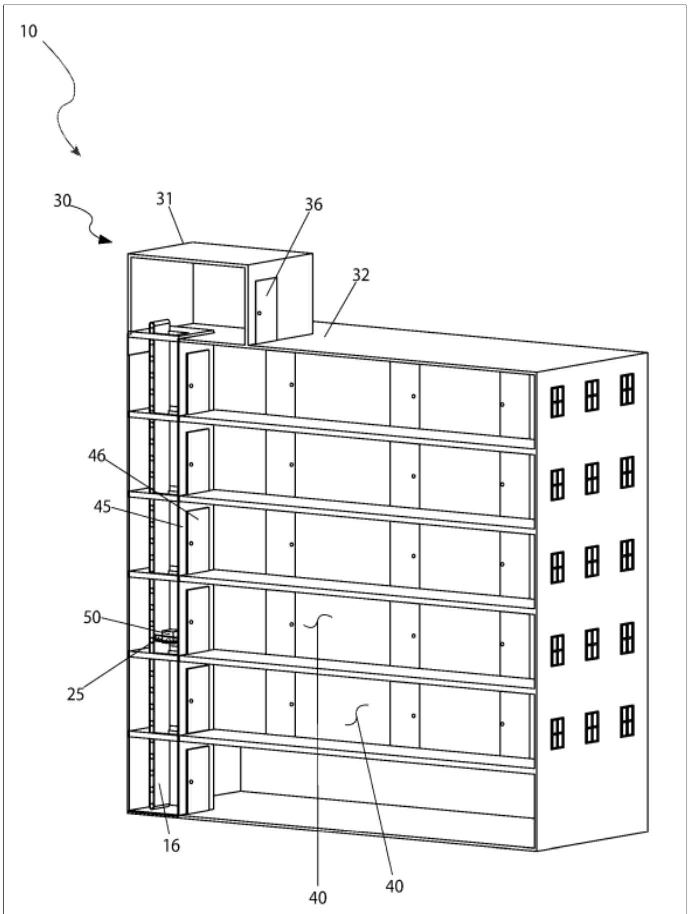

Fig. 2. Perspective, partially cut-away view of a multi-story structure with a multi-story package delivery system installed therein (compiled by author)

This end-to-end route reduces manual operations to one or two touches, which, according to business plan calculations, saves the courier an average of six minutes per address and eliminates up to 100% of resident contact during handover.

The key element is the motorized conveyor on a toothed chain (see fig. 3): it moves platforms at the speed of a delivery-service elevator while permitting intermediate lateral branches for flexible locker connections. A loading frame reads weight and dimensions to assign the optimal platform automatically, and the locker system allocates cells on a package-to-person basis, which is especially effective for recurring grocery orders. The aggregate throughput capacity of the baseline configuration is estimated at 720 average-sized units per hour with four stops per floor, sufficient to handle the peak volumes of a 40-storey residential complex on a Friday evening.

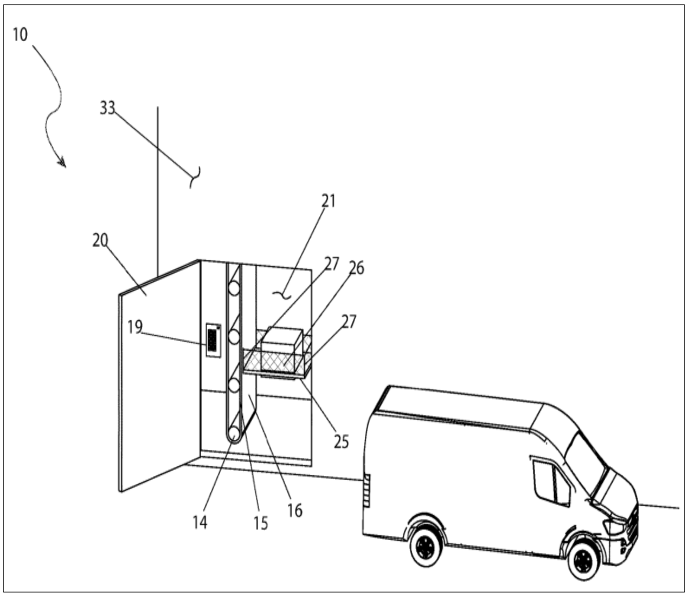

Fig. 3. Close-up view of a side of the multi-story structure, showing the initial placement of the package on the carriage of the system (compiled by author)

The technology is protected by a utility patent registered in 2023 and is explicitly positioned by the author as having no analogue on the vertical-delivery market. The patent claims cover both the principle of direct payload transfer through a shaft with dynamic branching into lateral lockers and the contactless authorization algorithm. North American standards design conveyor modules, specifically CSA B44 for vertical transportation and UL 508A for electrical panel equipment. This design allows for seamless integration into a building's standard core, eliminating the need for a separate fire safety review. As a result, developers can reduce risk and accelerate approvals while retaining complete legal protection against copying through patent and closed control interfaces.

At the architectural concept level, the vertical conveyor shaft is laid out simultaneously with the elevator and engineering cores. It runs as a continuous shaft from the receiving dock to the rooftop service area, so all openings are cast during the monolithic phase, and the building's structural grid requires no additional reinforcement. Conveyor modules are delivered to the site in assembled sections and installed at the same cadence as standard elevator rails, so floor-plan adjustments are limited to replacing one secondary shaft, typically leaving sellable floor area unaffected.

After physical installation, the equipment connects to the existing Building Management System. The latter receives data on load, power consumption, and diagnostics of key components from the conveyor controller, and in return, provides a unified authentication layer for couriers and residents. The business plan emphasizes that the Skyscraper Parcels vision is to become part of the ecosystem of other building-management systems; for this reason, the conveyor API is designed from the outset to be open to elevator dispatchers, security systems, and payment gateways, and the mobile application serves only as a user interface rather than a standalone automation island.

Visually, the system remains invisible: the receiving dock is located in the existing unloading area, the shaft is concealed behind the same fire-resistant gypsum cladding used for cable risers, and the floor-level lockers occupy a niche roughly as deep as a kitchen cabinet, finished with the same panels as the corridor walls. The entire operation is contactless: the courier scans a barcode, the platform retracts into the shaft, and the resident receives a notification of delivery readiness, thereby eliminating the need for in-person handoff and avoiding any conflict with lobby or façade design. Thus, vertical automation not only solves the logistics challenge but integrates into the architecture without compromising either spatial efficiency or building aesthetics.

Capital outlays for vertical automation are gauged by a simple yardstick: the expenditure per serviced floor. The financial sheet shows a set installation price of $25,000 per floor for equipment and mounting, which, in a typical 40-storey condominium, would run approximately $1 million without requiring extra structural reinforcement. This single-rate approach standardizes cost estimates for the developer, ensuring consistency across all projects. It simplifies comparisons with alternatives, such as adding freight elevators, which—according to industry rate cards—cost more while offering lower throughput.

Operating expenses are modeled as a service subscription, where the manufacturer provides remote monitoring, preventive maintenance, and firmware updates for the conveyor. The management company pays a regular fee based on the number of platforms serviced. The business plan stresses that establishing an in-house service team by the end of year 3 allows subscription costs to remain below the annual savings on manual logistics, thanks to scale and parts standardization. Although precise tariffs have not yet been disclosed, conservative assumptions are built into the IRR calculations, as evidenced by the gap between revenue and net income.

Revenue for the developer is realized immediately upon unit sale: buyers are willing to pay a premium of $4,000 per apartment in Canada and $6,000 in the United States for guaranteed contactless delivery, as confirmed by the project's financial model. At a conversion rate of just 5% of Canadian high-rise projects, the internal rate of return (IRR) is 14.4%, with a nine-year payback. At a 50% conversion rate, the IRR rises to 42% and the payback shortens to five years. These figures already account for the service subscription and gradual cost reductions from localized production after year 2.

From a scaling perspective, the North American market is estimated by the author at $250 million for Canada and $111 million for the U.S., based on 3,342 and 1,482 floors under construction at the end of 2020, respectively. Even with the original cost structure, this covers only a portion of global demand: Asia's and the Middle East's megacities annually add more high-rise floors than the entire Canadian market, so replicating the technology promises further revenue growth with minimal adaptation costs, since the core engineering platform and patent protection are already in place.

The transition from engineering concept to industrial operation begins with a full-scale prototype installed in a demonstration skyscraper, serving real delivery volumes for six to ten months; during this phase, conveyor dynamic loads, locker-addressing algorithms, and failure scenarios are refined so that by the time the technology is deployed to new sites, the turnkey configuration is validated by operational data. Prototype testing serves not only as an engineering proof of concept but also as a marketing tool: developers and delivery services can experience the system and verify courier-time savings before a project reaches the market.

Concurrently with physical trials, the digital loop is deployed: the software team links the conveyor to Amazon, Uber Eats, and national postal platforms via the open API and releases a mobile application for residents; development of this layer spans from month 6 to month 20 and culminates in a state where any service recognizing GS1 barcodes can initiate delivery directly from the receiving dock without further integration. This step fulfills the critical condition for commercial viability—universal compatibility—while creating a network effect: the more platforms connected, the greater the system's value to each new building.

After the release of the integrated version, the focus shifts to scaling: a supply chain of standardized components is established, installation teams are recruited and trained, and initial equipment batches are assembled under contract manufacturing. By month 24, the project transfers conveyor-module production to its own—or long-term outsourced—workshop, reducing unit cost and ensuring quality control; by the end of year 3, the service department is fully staffed, providing 24/7 monitoring, spare-parts warehousing, and field maintenance, thereby transforming the product into a fully supported building-engineering system.

Thus, the entire roadmap is completed within 36 months: the first 10 months are devoted to validating the technical hypothesis, the next 10 months to creating the digital ecosystem, the subsequent 12 months to launching serial production, and the final 6 months to establishing the service infrastructure. This sequence minimizes investment risk, since each subsequent phase commences only after clearly defined milestones of the preceding phase have been met, and the positive impact of the prototype and early integrations already begins to generate demand for serial production.

For residents, the automated system converts delivery into a contactless background process. After scanning the barcode, the parcel immediately enters the shaft and arrives at the floor-level locker, eliminating the need to meet the courier or carry packages through elevators. The executive summary emphasizes that this is contactless delivery ... straight to the floor or apartment, thereby reducing not only episodic infection risks but also the cumulative stress of waiting and queuing.

For developers, this same premium is converted into additional revenue per sold dwelling unit and significantly improves project investment metrics. Because the equipment is integrated at the structural-core level and does not reduce sellable floor area, the achieved margin is scarcely diluted by incremental construction costs.

Delivery services benefit from eliminating the most time-consuming segment—the elevator wait and manual recipient search. The business plan forecasts annual reductions in operating expenses through order combinations and higher courier throughput enabled by automatic unloading and precise parcel delivery. For platforms, this means the ability to process more orders with the same workforce and to reduce late-delivery penalties, since internal building delays are removed from the critical path.

The urban environment indirectly benefits from reduced courier traffic at entrances. When parcels can be deposited at the receiving dock, repeat van stops and double-parking on narrow sidewalks become unnecessary. Noise levels decrease, pedestrian and micromobility lanes are freed, and machinery, rather than people, bear contact loads on elevators and common areas. Ultimately, a single engineering module simultaneously enhances the quality of life, real estate investment appeal, logistics service efficiency, and urban infrastructure sustainability.

In summary, integrating vertical automation into the structure of modern high-rise buildings not only radically reduces temporal and economic losses in the last mile but also decreases carbon footprint and sanitary risks associated with dense courier and resident traffic. Through the thoughtful combination of conveyor shafts, modular lockers, and intelligent elevator management, the internal last mile evolves from a disjointed chain into a coherent engineering system, embedded at the design stage and seamlessly integrated into architectural cores.

CONCLUSION

This study demonstrated that the integration of full vertical automation within high-rise building structures effectively transfers last-mile logistics flows from the street into the internal building engineering systems. It has been shown that post-pandemic growth in electronic shipments creates critical congestion problems inside these internal parts of high-rise complexes, where conventional elevator cores and corridors are not built to handle high-density courier traffic. The proposed architectural system—combining a receiving dock, a toothed conveyor, and multi-level lockers—reduces courier in-building time by an average of 78%, eliminates multiple contact points during parcel handover, and lowers total last-mile costs to 28% of aggregate expenses.

The Skyscraper Parcels technological platform, protected by a utility patent and compliant with CSA B44 and UL 508A standards, enables the integration of a vertical conveyor into standard building cores without requiring additional structural reinforcement, significantly streamlining approval procedures. This approach preserves both the spatial and aesthetic integrity of façades and lobbies while ensuring seamless integration with existing building management systems via an open API, thereby establishing conditions for scalable deployment in response to the global demand for internal logistics hubs.

Economic analysis indicates that, at an installation cost of $25,000 per floor and a buyer premium of $4,000–$6,000 per apartment, the project delivers developers an attractive internal rate of return (IRR) of 14.4%–42%, depending on conversion rates, with payback periods of five to nine years. The operational benefits of the delivery services include a reduction in unproductive elevator waiting time and quicker courier turnaround, which can significantly impact profitability when handled using traditional methods. The offered model of vertical automation eliminates temporal and economic waste. It reduces carbon emissions and public health risks associated with close contact between couriers and residents. Prototype deployment and scaling the production, as well as service support, make technology adoption feasible in new projects. It also sets the stage for opening more paths of monetization for developers while enhancing the sustainability of urban logistics systems in post-pandemic times.

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