Strategic Design for Delivery with Linked Transportation Assets: Trucks and Drones

tech transfer summary

Hybrid truck-drone delivery systems have the potential to provide substantial cost savings, especially in suburban areas.

Objectives

The objectives of this project were to provide a strategic analysis for the design of hybrid truck-drone delivery systems using continuous approximation modeling techniques and to derive general insights into the viability of using drones for home and business delivery as an alternative or complement to traditional truck-only delivery.

Problem Statement

Despite the increased interest from major retailers and services in using drones for parcel delivery, companies have not yet determined the fundamental issue of how best to deploy drones for home and business delivery.

Background

Previous reports have suggested customers and companies desire use of drones for delivery and that there's a relatively low cost to incorporate them into delivery models, but there is a need for additional research on how best to use drones in delivery models. Proposals for methods of drone delivery vary from independent use to using them in conjunction with delivery by trucks, but there has not been research into the best implementation.

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MTC RESEARCH PROJECT TITLE
Strategic Design for Delivery with Linked Transportation Assets: Trucks and Drones

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The Midwest Transportation Center (MTC) is a regional University Transportation Center (UTC). Iowa State University, through its Institute for Transportation (InTrans), is the MTC lead institution.

MTC's research focus area is State of Good Repair, a key program under the 2012 federal transportation bill, the Moving Ahead for Progress in the 21st Century Act (MAP-21). MTC research focuses on data-driven performance measures of transportation infrastructure, traffic safety, and project construction.

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Research Description

The research team sought to answer two questions: How can delivery companies and other organizations best use hybrid truck-drone routes to serve a region, and how do those hybrid routes compare with truck-only delivery?

The team formulated continuous approximation models using trucks and drones and compared the results with truck-only deliveries. The modeling used reasonable parameter values and operating characteristics to evaluate a range of delivery models, from rural to suburban regions, and highlighted key areas for beneficial drone operations.

The modeling also weighed a variety of operating costs and utilized different numbers of drones operating with the delivery trucks.

The team sought to minimize expected costs for deliveries across a given region. The research focused on truck-drone delivery where the drones are autonomous vehicles making deliveries on their own, with each drone departing from and returning to a truck and carrying only small parcels. Although the research focused on such specifics, the modeling was flexible enough to allow for analysis of a range of drone types and delivery strategies.

The research focused only on logistical and operational aspects, not legal, regulatory, and technological issues.

Key Findings

The results suggest truck-drone delivery can be very advantageous economically in a variety of settings, particularly with multiple drones per truck, but the benefits depend heavily on the relative operating costs and marginal stop costs.

More specific findings include the following:

- Truck-drone hybrid delivery has the potential to provide substantial cost savings, especially in suburban areas.
- Incorporating multiple drones per truck offers important but marginally decreasing savings that can be large.
- The benefits from truck-drone delivery depend strongly on the relative operating costs per mile for trucks and drones, the relative stop costs for trucks and drones, and the spatial density of customers.
- Measures of savings per delivery and savings intensity per square mile provide complementary perspectives that highlight the conditions and regions likely to generate the greatest savings.

Implementation Readiness and Benefits

The mathematical expressions and models developed will be an important assessment tool to determine the best use of truck-drone delivery and the expected economic performance of different delivery systems. The ability to compare expected delivery costs for different delivery systems will help identify when and where implementing a hybrid truck-drone delivery model is likely to be most beneficial.

The mathematical expressions in the models were optimized to determine important drone delivery system design parameters, including the optimal number of truck and drone deliveries per route, the optimal number of drones per truck, and whether truck-only or hybrid truck-drone travel provides a lower total cost.

The models also incorporated travel time constraints and vehicle capacity limits to increase their realism. While the research focused on these parameters, the modeling is flexible enough to allow for analysis of a range of drone types and delivery strategies.

Recommendations for Future Research

A more detailed analysis to identify real values of cost per mile and cost per stop would be useful. While the models developed for this project provide general insights, future research on demand, population density, and the operating characteristics of drones and trucks, such as vehicle speeds and stop costs, would be beneficial.