Can mixed-mode logistics fleets including drones really decarbonise freight?: Grounding the myths using case study modelling

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Interest in using drones (a.k.a. un-crewed aerial vehicles, UAVs) in logistics has been rapidly growing in recent years, with many trials taking place worldwide to prove the concept; however, to date, very few have reached the point of sustained commercial operation. Drones are often touted as a key solution for offering i) cheaper and faster delivery services (e.g. within an hour), ii) removing congestion from roads, and iii) cutting greenhouse gas and polluting emissions from a range of environments, though many of these theorised benefits may not apply in all cases. This paper seeks to understand to what extent drones, integrated into existing van-based medical specimen collection services can bring about such improvements, by applying practical assumptions in a novel modelling suite that identifies the best circumstances for their use alongside traditional road-based modes.

The logistics behind the UK National Health Service (NHS) is one particular use case that is being explored for expediting delivery whilst decarbonising fleets. With the NHS actively exploring how more sustainable and innovative transport modes can be used alongside traditional logistics systems to support their target of reaching net-zero emissions by 2040, the introduction of drones might be beneficial; however, this is not necessarily true. Using NHS patient sample delivery data as a case study, this investigation seeks to understand the benefits of using drones as part of a mixed-mode fleet, consisting of vans/trucks, cycle couriers, and drones in two areas – Southampton and the Isle of Wight in the UK.

Accounting for numerous factors, such as the potential airspace management challenges, third-party ground risk, weather limitations, and the practical payload requirements, a combinatorial optimisation approach is used to identify the benefits of using drones alongside, or in place of road freight vehicles. The proposed model uses an adapted Clarke and Wright Savings Algorithm with an adapted Bin Packing Algorithm to produce effective solutions quickly and efficiently. Cost analyses based on aviation industry maintenance practices were used, enabling realistic comparisons between road freight and air freight modes.

Business-as-usual analysis indicated that the 79 GP surgeries in the Southampton area (England) generate some ~3,000 samples each weekday, which are collected using 10 van rounds, with many surgeries visited twice daily. Owing to the practical landing space requirements, only 9 out of 79 surgeries could be realistically and safely served by a drone, sufficiently large enough for the required payload unit. A larger proportion of the Isle of Wight's surgeries (6 out of 22) could be safely served by drone served, though the smaller total number meant that the potential for drone service is reduced due to van services already having residual capacity.

Under these scenarios, initial modelling results indicated that drones offered no significant cost or environmental benefits over cycle and van driven freight, in part due to sites in the vicinity requiring servicing, even if a drone visit was possible.

In a different scenario where drones could be permitted to serve any site, modelling indicated that whilst deliveries could be made faster if drones were able to serve all sites, a significant increase in emissions costs would result due to the need for drones to cover almost 5x the total distance of vans as a result of their limited capacity. Whilst cutting delivery times will help to reduce the need for 're-bleeding' samples from patients due to expiration, the level of time saving experienced is likely to have minimal benefit in terms of onward care without further investment in laboratory analyses and subsequent treatment programming to reduce the possible bottlenecks elsewhere in the patient care system.

The best improvement in emissions came from introducing cycle consolidation into the system; for example, replacing 2 vans with 16 bike routes and 1 drone enables a 17% reduction in emissions in the Southampton area, when drones are permitted to serve all sites.

The results have demonstrated that drones cannot easily compete with traditional logistics vehicles due to the economies of scale in vans and the current costs of drone services. Furthermore, where there is availability of reliable and flexible ground transport modes, drones rarely offer genuine benefits in terms of time or emissions savings. In more remote regions, where traditional transport is slower and less reliable, there may be some scope for drones, though their use in the wider transport network should be considered, in addition to potentially more beneficial alternatives. The results can assist policymakers in deciding where drones may have better use, and how mixed-mode fleets can be adopted into healthcare logistics.