Designing unmanned aerial vehicle networks for biological material transportation

Dhote Jeremy and Limbourg Sabine*

HEC-University of Liege, QuantOM, rue Louvrex 14, 4000 Liège, Belgium
*Corresponding author

1. Problem and research questions

Rapid growths in Unmanned Aerial Vehicle (UAV) area over the last decade have led to innovating applications in several industries (Beloev 2016; Hassanalian & Abdelkefi, 2017; Wisniewski & Mazur 2016). This new type of vehicle may solve, or at least reduce, the negative impacts of road transport such as pollution or congestion. Particularly, propensities of UAVs to be autonomous, modular, fast, with a high reactivity, are serious inducements for using them in the specific field of biomedical transportation. Medicines, vaccines, units of blood require prompt response for delivery when the need arises. Beyond the development of the technology of UAVs, deep changes are being to occur in logistic activities, as the breakaway with traditional transportation systems is huge. Establishment of the frame of this new business model is in progress.

This study deals with the UAVs network design problem for biomedical material transportation in line with the Drone4Care project (Data News, 2018). The logistical issues are investigated, to understand the prerequisites for the deployment of UAVs, imagine new solutions, determine optimal locations for UAVs launch bases, and evaluate the impact of principal variables on UAVs network arrangement and performances.

2. Methodology, research strategy

As our goal is to shape the general guidelines and policies of the UAVs network for biological material with an impact that resonates through a long term; we begin with a PEST analysis to provide an overview of the various macro-environmental factors to be taken into consideration. To specify the objectives of the project and identify the internal and external factors that are favourable and unfavourable to achieving those objectives, a SWOT analysis is also performed. The elevated issues are translated into a number of quantifiable scenario elements, containing the most plausible upcoming events impacting the future of UAVs network for biological material.

The deployed techniques come from the field of Operations Research, addressing a strategic, long-term decision horizon. A mixed integer linear program is formulated and handled by the solver IBM ILOG CPLEX 12.8 in its default setting. The developed location model is applied to the city of Brussels and periphery, with associated market in terms of biomedical products flows (blood units or medical samples transported between hospitals, laboratories, and blood transfusion centres) in the context of separate case studies of scenario-based analysis.

3. Major findings

We discuss here the results with respect to the studied scenarios. The experiments show that:

- If the return to the launching base is required, the total distance is greater than if this constraint is relaxed. This is a crucial point regarding limited range of UAVs. However, the latter, implies to reposition UAVs due to imbalance flows.
- The use of charging stations is useful to extend the mission ranges and gain market share.

- In what concerns a progressive deployment, the first results show the possibility of gradually implementing the bases, without requiring any major changes such as to close a base.

4. Takeaway

In order for a clear advantage of UAVs over traditional transport schemes to materialize, we underline the importance of various variables with more weight accorded to the most significant ones. Model and results obtained are of interest as decision-support tools, in the process of UAVs network deployment for biological material transport, by helping to evaluate consequences of strategic choices. In addition to the results presented for Brussels, this research on the optimal location of the bases highlights the importance of the technical characteristics of the UAV (range, speed, payload). This work will be integrated into the Drone4Care project.

5. Keywords:

Unmanned aerial vehicle, Network design, Biologistics, Operations research

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