Modeling Unmanned Aerial Vehicles (drones) Costs

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Long Beach - October 19, 2017
Modeling Unmanned Aerial Vehicles (drones) Costs

Several papers in one presentation

Minimum formulae/numbers in this presentation

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Motivation - Urban Delivery Landscape

- Congestion
- Pollution – air, water, and noise
- Pressure to meet environmental mandates
- Scarcity of parking in urban areas
- Rapid increase in package deliveries and service calls
- Urban population growth
- Growing markets (online, real-time)
“reinventing” the last-mile

Conventional supply chain with truck last-mile deliveries

“New” supply chain with drone last-mile deliveries
Survey of UAV capabilities

- Methodology: extensive internet search
- Information on websites along and downloadable material
- In some cases, customer service was contacted to request additional information.
- **21 UAVs** currently available in the market.
Speed, Flying Times, Ranges and Payloads

• Speeds: Most speeds are in the range of 16 to 20 meters per second (35 to 45 miles per hour)

• Flying times: 20 to 30 minutes.

• Ranges: heavily dependent on a multitude of factors (payload size, weather, flown within LOS etc.). Typical range 15 - 35 kms (~ 10 - 22 miles).

• Payloads: affect range, depending on configuration, typical 6.4 kg to 1.8 kg. (14 to 4 lbs).
UAV Cost vs. Performance/Characteristics

- Strong correlations among UAV cost and key vehicle characteristics
- Also analyzed relationships among cost, battery (energy), weight, payload
- Developed cost and performance models
Cost Analysis

- Vehicle costs
- Battery costs
- Labor costs
- Energy costs

- Not focusing on other costs (overhead, fixed costs)
### Some Results: impact of distance

<table>
<thead>
<tr>
<th></th>
<th>UAV</th>
<th>Battery</th>
<th>Energy</th>
<th>Staff</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average trip distance ~15 kms</td>
<td>73.0%</td>
<td>10.7%</td>
<td>0.6%</td>
<td>15.8%</td>
<td>100.0%</td>
</tr>
<tr>
<td>10 UAVs per staff</td>
<td></td>
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<td></td>
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<tr>
<td>Average trip distance ~30 kms</td>
<td>85.4%</td>
<td>6.3%</td>
<td>0.3%</td>
<td>8.0%</td>
<td>100.0%</td>
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<tr>
<td>10 UAVs per staff</td>
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<tr>
<td>From ~ $0.7/km to $1.2/km</td>
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</tbody>
</table>
Some Results: impact of labor

- Average trip distance ~15 kms
- 10 UAVs per staff

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<thead>
<tr>
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<th>Staff</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
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<td>UAV</td>
<td>73.0%</td>
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<tr>
<td>Battery</td>
<td>10.7%</td>
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<tr>
<td>Energy</td>
<td>0.6%</td>
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<tr>
<td>Staff</td>
<td>15.8%</td>
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<tr>
<td>TOTAL</td>
<td>100.0%</td>
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</table>

- Average trip distance ~15 kms
- 0.9 UAVs per staff

From ~ $0.7/km to $1.8/km

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<tr>
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<th>Battery</th>
<th>Energy</th>
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<th>TOTAL</th>
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<tbody>
<tr>
<td>UAV</td>
<td>28.1%</td>
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<tr>
<td>Battery</td>
<td>4.1%</td>
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<tr>
<td>Energy</td>
<td>0.2%</td>
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<td>Staff</td>
<td>67.5%</td>
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<td>TOTAL</td>
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Still some economic/logistical advantages when certain conditions are met:

- Low density
- Remote locations
- Faster access / urgency
CO$_2$e tradeoffs: UAVs lifecycle analysis

• Relatively low per-mile emissions
• Relatively high vehicle phase emissions

• UAVs very CO$_2$e efficient (per-unit distance)
• EVs and Tricycles more CO$_2$e efficient with multiple dropoffs (medium density)
Cost Analysis by Drone Type

- Multicopter (MC)

vs.

- Fixed-wing (FW)

With or without VTOL*?

*VTOL: vertical takeoff and landing

UAV Cost vs Performance tradeoffs
Battery Cost Trends

• Battery industry-wide cost estimates declined by approximately 14% annually between 2007 and 2014 (from US$1,000 per kWh to US$410 per kWh)

• Somewhat important impact on vehicle capital costs

• Improvements to logistical capabilities?
Some Conclusions

• High cost per delivery when compared to traditional *ground* parcel deliveries
• Significant impact of distance and regulations
• Dynamic and uncertain cost variables and many potential scenarios
• New applications and/or markets
Related UAV Publications


• Figliozzi and Tucker, What can multicopter drones deliver? A survey and analysis of the capabilities and limitations of state of the art drones, Working paper


• Figliozzi M., Economic and Market Analysis of Drone Deliveries, Working paper.
Acknowledgements

• Freight Mobility Research Institute (FMRI) funding UAV-drone research

• Chad Trucker, Graduate Research Assistant
THANK YOU

Questions? Comments...

Visit the TTP Lab webpage:

http://www.pdx.edu/transportation-lab/

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