

Creating open collaborative coverage maps at drone operating altitudes

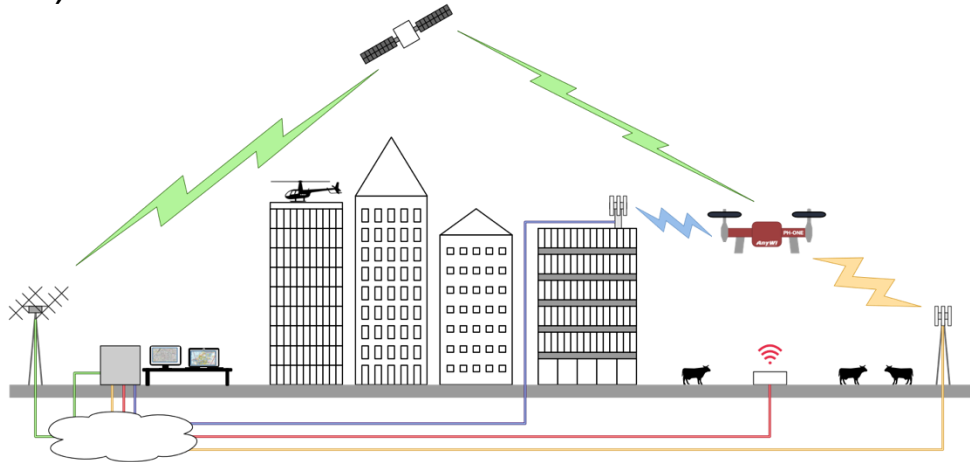
2nd workshop on open science in aviation

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Can drones be useful?

- ... for instance, operate in all the well-hyped use cases of parcel delivery, rescue operations, inspection of sea-based wind turbines, etc?
- A possible business case is to substitute expensive (manned) helicopter flight hours with long-range drone operations (known as BVLOS)
- This requires – among other things – a reliable data link for command and control (C2)



Relevant regulatory frameworks

- Flight beyond visual line of sight is becoming possible in Europe
 - In **normal airspace**, with possible presence of manned aircraft (class G)
 - This is covered by Specific Operations Risk Assessment (SORA)
 - **Segregated airspace** reserved for drones
 - This is covered by U-space
- In both cases, a C2 link is required for safe operation and to fulfil a regulatory requirement for a remote pilot in control of the drone
- Note that this is for BVLOS ops, which by definition are Specific Operations



Image: Avy



Image: Pipistrel



Image: Volocopter

C2 link for BVLOS

Some customer needs for the C2 link:

- Economical
- Low technical management overhead
- Possibly supported by technical experts

Commercial, public mobile networks are good candidates for data links

Strengths

Economical, widespread, supported

Familiar technology

Weaknesses

Outside the control of UAS
manufacturers and operators

Not designed for drones

“Reliability”

- Consider public networks as “black networks”
 - Very little relevant information about performance, service guarantees, etc.
- One solution is to gather the information ourselves
 - Define Quality of Service metrics relevant to C2 links for BVLOS operations
 - Make measurements in the relevant airspace
 - Store them in a suitable database
- Use the data in the approval process for your BVLOS operation
 - Or your U-space

How to collect data

- Fly around and measure the quality of service (QoS) of the link(s)
 - Store the information in a data base
 - Possibly by a dedicated probe unit in the payload
 - ... but if you have access to the software of the C2 link, you can add it on
- In practice, the information must be collected from inside the data link
 - From the drone by measuring QoS to the ground
 - ... or vice-versa, depending on the network architecture
 - So not fully “open data”
- No simple way to measure it from “neutral” ground receivers
 - The data packets transmitted between drones and ground are encrypted
 - Unlike ADS-B or similar protocols

Data probe

- A powerful data probe and test data link gateway
- Batteries not included
- What do you mean, “SWaP?”



Quality of service data collected by drone

Create a 3D map of quality of service based on relevant parameters.

In this case, round-trip time (RTT)

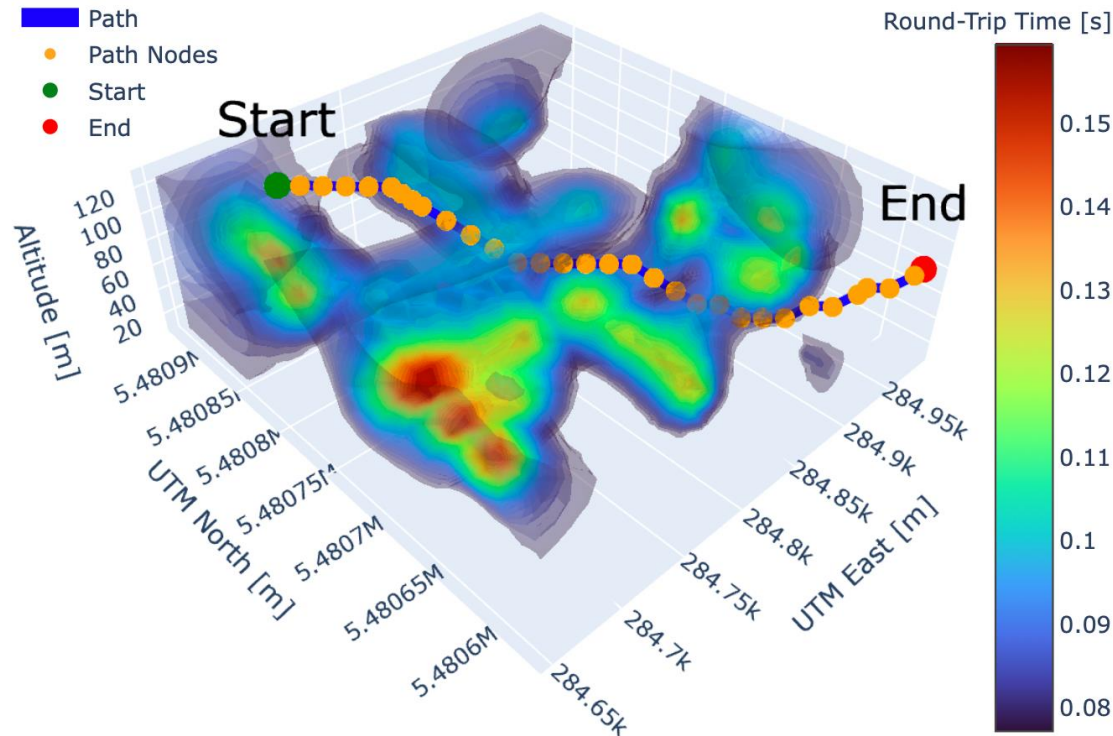
- Data available on Zenodo

Reference: Purucker et al: Deep Neural Quality of Service Prediction for Unmanned Aircraft System Communications

2024, DOI:

10.36227/techrxiv.172555439.95

715599/v1



What do the QoS data look like?

- Data formats
 - A tree-structured collection of numerical and symbolic data
 - A large number of data points per cell tower, of which only a few are relevant
 - A variable number (sub-)records describing neighbouring towers
- Can be aligned with open-source data bases of cell towers
 - For instance, opencellid.org for cell IDs and other network identification data
 - Infrequently updated
 - Probably most relevant for U-space given the uneven coverage of the database

How could the Tangram software fit in?

- As an open source data base where necessary fields can be added to store unstructured information about neighbouring base stations
- Ready to tag entries with aviation-centred meta data
 - 3D (4D) coordinates
 - Aircraft identifier
 - Possibly be ready for iConspicuity (ADS-L, Flarm, etc.)
- Infrastructure to receive data on the fly
 - ... and, presumably, ingest data off-line

Thank you!

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