Separation in the U-space Concept of Operations

An overview for Drone Enable 3

Andrew Hately
CORUS technical coordinator
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CORUS very briefly

- CORUS is:
- SESAR2020 Exploratory Research project
- Developing a Concept of Operations for U-space
- Stakeholder consultation is central to CORUS:
- 9 consortium members
- 21 member advisory board
- 70+ cooperating organisations in
  - 8 “sibling” projects simultaneously explore technology questions
  - 10 related demonstration projects
- 600+ member U-space Community Network

- Over two years CORUS has
- Run three large workshops

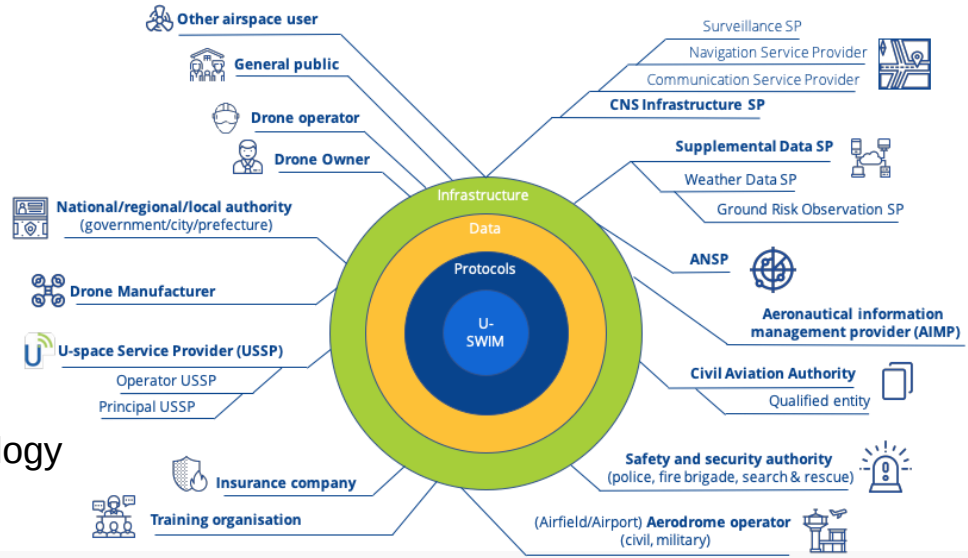
- Iteratively developed a ConOps

- https://www.eurocontrol.int/project/concept-operations-european-utm-systems

The CORUS project has received funding from the SESAR Joint Undertaking under grant agreement 763551 of the European Union’s Horizon 2020 research and innovation programme.

CORUS & U-space

- U-space is initially concerned by VLL
  - = below VFR, but including CTR
- U-space can be thought of as serving small drones
  - In fact it serves anything flying in the volume
- U-space is defined as a set of services
- The U-space principles are
  - Safety first
  - Social acceptance
  - ECAC wide
  - Open market
  - Equitable access
- CORUS aims to create a robust ConOps
  - allowing a high level of traffic
- CORUS main concern is traffic management
- CORUS makes few assumptions about technology



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Airspace Volumes

- Focus on VLL
- All of VLL is divided into: X, Y or Z volumes
- X = low risk
- Y = medium risk & density
- Z = highest density
  - Za = ATC controlled airspace
  - Zu under U-space

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Airspace and Conflict Resolution

- X:
  - No conflict resolution
  - Pilot remains responsible to remain well clear
  - enables VLOS
- Y:
  - Approved flight plan required
  - Strategic Conflict Resolution
    - = before take off
  - Flights which conform to their plans have an acceptably low * probability of encountering each other
    - Unless previously agreed e.g. VLOS
  - * = acceptable to the regulator
- Z:
  - Conflict resolution
    - Strategic = before flight
    - **and** Tactical = in flight
  - Za
    - ATC controlled airspace, e.g CTR
    - U-space provides
      - Situational awareness to ATC
      - Communication tools
      - Standard ways of working
  - Zu
    - U-space (software) provides conflict resolution during flight, from the ground

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Drones in the Za volume

- The ATCO remains in charge
  - The aim is to make the drones controllable
  - U-space provides supporting services
- The separation is as other aircraft
  - The drone is lighter, smaller and slower
  - The ATCO determines the spacing
    - Wake vortex and micro-weather will be significant
- U-space planning
  - Flights into Za are planned in U-space
  - The U-space flight plan is used to coordinate Za entry and operation
  - The plan can be used tactically by the ATCO

U-space surveillance

- U-space tracking may be based on technology not used by manned aviation
- U-space tracks can be supplied to ATC
  - Tracker to Tracker
- To be shown on the normal ATC displays

- U-space Communications
  - We do not require drone pilots to be familiar with R/T phraseology
  - We do not expect drone operators to have VHF radios
  - U-space can provide *CPDLC-like* communications between ATCO & Pilot
  - U-space should convert heights and headings to the appropriate systems

PICTURE: By Bruno Dantas - Self-photographed, Public Domain, https://commons.wikimedia.org/w/index.php?curid=1554258

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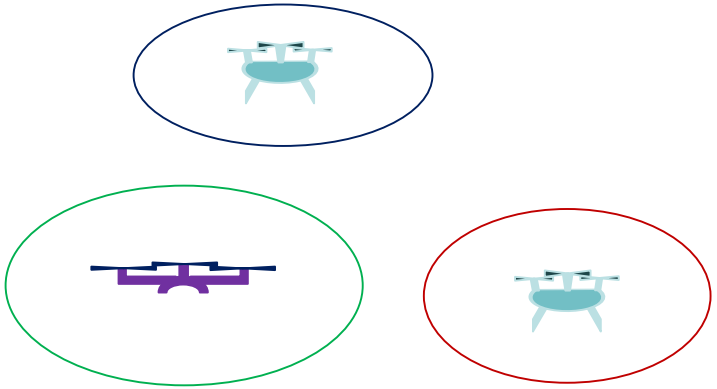
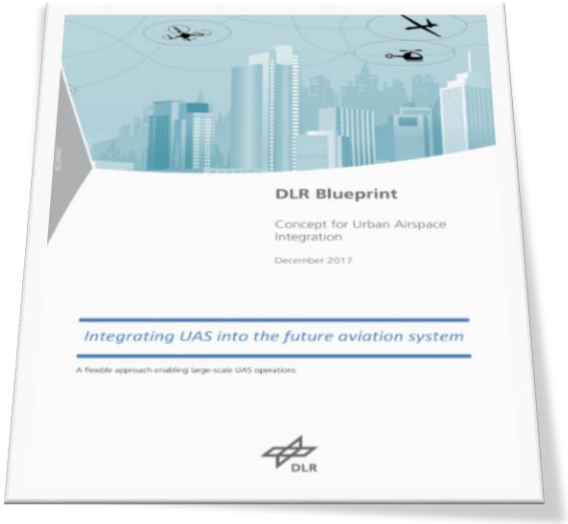
The Zu volume and bubbles

- Tactical conflict resolution by computer
- Pair-wise separation minima
- Each aircraft is surrounded by a bubble
- The minimum safe distance prevents to bubbles touching



- This idea has been discussed by several
- CORUS partner DLR looked at the idea in some detail in “Concept for Urban Airspace Integration DLR U-Space Blueprint



https://www.dlr.de/fl/en/Portaldata/14/Resources/dokumente/veroeffentlichungen/Concept_for_Urban_Airspace_Integration.pdf

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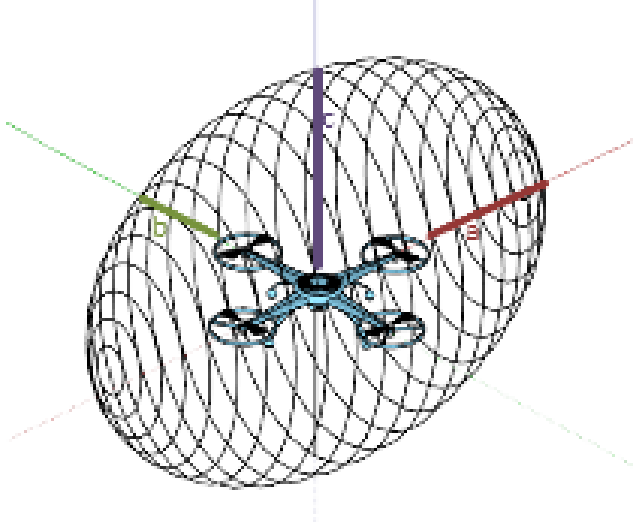
The Zu volume and bubbles



- The size of the bubble for one aircraft in any volume at any moment considers two sets of factors
  - CNS performance
  - Risk: How ‘serious’ a collision with this vehicle would be.

- CNS:
  - The navigational performance of the aircraft
  - External factors such as current weather conditions
  - The performance of the communication between U-space and pilots
  - The performance of the surveillance function
- Risk related to the aircraft
  - The size and weight of the aircraft
  - The instantaneous velocity of the aircraft
  - Presence of hazardous cargo or passengers
- Risk related to the location
  - What is on the ground being overflown

Diagram extracted from Fig 3 of DLR’s “Concept for Urban Airspace Integration DLR U-Space Blueprint

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Zu: The U-space Tactical conflict resolution dilemma

If the tactical separation messages from U-space are instructions, then

- The U-space Service Provider (USSP) is providing a separation service.
- Zu is controlled Airspace (e.g. class B ?)
- The USSP needs
  - Software & hardware certified to the highest standard
  - Insurance commensurate with the liability
- Both communications between USSP and pilot and also the position reporting of the aircraft towards U-space need to be
  - Low latency
  - Safety-of-life reliable

If the tactical separation messages from U-space are advisory, then

- Zu is uncontrolled Airspace (e.g. class G ?)
- Responsibility rests with the Pilot
- Spacing may be *rather cautious* and traffic density relatively low
- There may be a dependence on detect and avoid
- Communications reliability & speed has safety implications.

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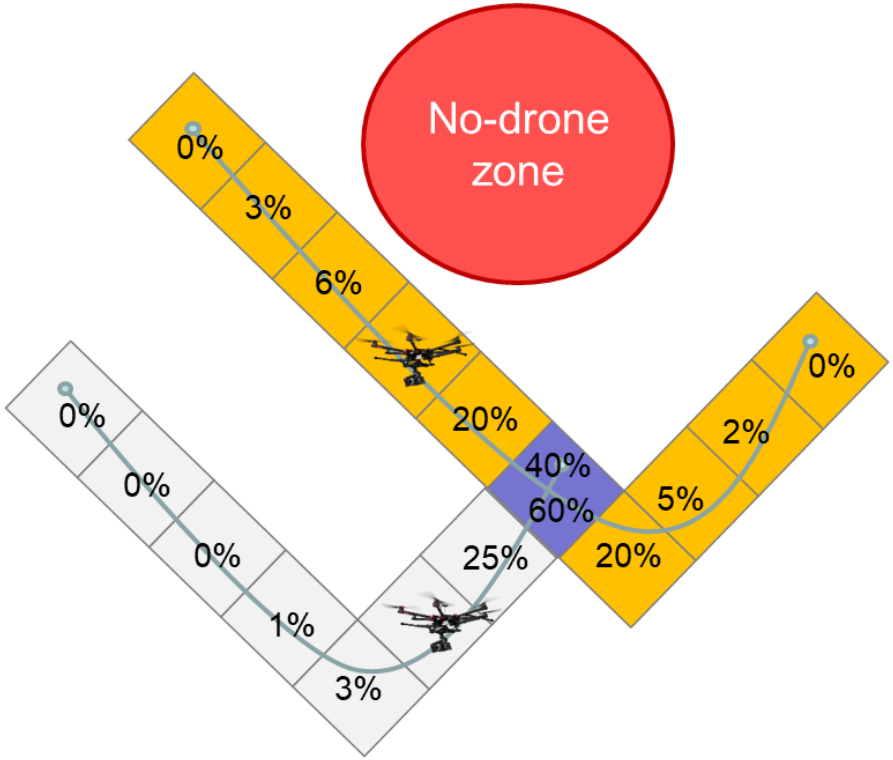
Pairwise Strategic (pre-flight) conflict resolution with Bubbles

- Conflict Detection is done
  - by the Operation Plan Processing service
  - on receipt of an Operation Plan
- A probabilistic 4D trajectory is extracted from the operation plan
- This is then compared with all others
- When the probability of a bubble intersection exceeds some predefined value
- Then a conflict is declared
- Conflict resolution can be
  - Imposed by the conflict resolution system
  - Or Collaborative
    - operator – conflict resolution system
    - operator – operator



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The timing of Strategic (pre-flight) conflict resolution

- Operations can have static priority
  - E.g. Life-saving operation
- Operations can also have temporary priority
  - Determined by Equity considerations

- Operation plans may be filed at any time.
  - Inspection operations can be planned in advance
  - Food delivery is often rapid turnaround.
- Fair treatment of different business not compatible with “first to file reserves the airspace”
- Pre-flight conflicts can appear at any moment before flight.

- Conflict resolution can either be
  - Continuous
  - Delayed until some reasonable time to act RTTA
- Plans arriving after RTTA have temporary low priority
- Conflict resolution all at RTTA can be optimised.
  - The picture is effectively complete

- Optimised conflict resolution at RTTA requires ‘control’ of the deconfliction by the conflict resolution engine
  - The inputs (plans) should not change

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Conclusions & Open issues

- Tactical separation from the ground is possible based on planning and surveillance.
  - Surveillance is likely to be dependent
  - Comms reliability and latency become crucial
- Separation depends on risk

- Strategic separation is possible based on flight planning.
- The separation between flights will depend on
  - The acceptable level of risk
  - The accuracy of the information available
  - The level of confidence in the flights conforming to their plans

Work is needed:

- Tactical separation
  - Surveillance methods
  - Communications
    - The CPDLC-like service for Za
  - Responsibility & Liability
    - Is Zu controlled aisrpace
  - Implications for manned aviation
- Strategic separation processes:
  - Processes between USSP, scaling conflict resolution
  - Priorities
  - Timing – when to deconflict
  - Fairness & acceptability
  - Legal underpinnings – does the USSP have the right to refuse a flight plan?

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