Separation in the U-space Concept of Operations

An overview for Drone Enable 3

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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
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
  - Open market
  - Social acceptance
  - Equitable access
  - ECAC wide

- 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
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
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
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

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 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/ll/en/Portaldaten/14/Resources/dokumente/veroeffentlichungen/Concept_for_Urban_Airspace_Integration.pdf
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.
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
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
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 airspace**
  - 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?