Integration of UAV into civil ATC/ATM
ATM-Simulation

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Heinrich Dörgeloh, Bernd Keck, Elmar Klostermann, Dirk-Roger Schmitt, DLR
Simulation Concept for UAV Integration

- VHF COM
- SSR transponder
- strobe lights
- TCAS II
- sense & avoid
- relay C³ link
- direct C³ link
- telephone
- UAV Control Station
- C-UAV
- Avionics System (NAV / FMS / AFCS / FTS)
- Other aircraft
- Air Traffic Control
- Comm delay

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Real Time Simulation

Mission Scenario:
- Surveillance Mission of a MALE UAV
- from regional airport Frankfurt-Hahn
- to mission area north of Bautzen

Scenario of Real Time Simulation:
- UAV crossing TMA Frankfurt on its outbound and inbound flight
- UAV emergencies within the TMA
Objectives of ATC/ATM Real Time Simulations

Evaluation of the UAV integration concept:
- Normal operations
- Emergency Operations:
  - Standard emergency procedures:
    - Comm Loss
    - Thrust Loss
  - UAV specific emergency procedures
    - (additional emergency codes)

Investigation of UAV specifics:
- Communication delay for voice and data
UAV events to be evaluated by simulations

- Loss of Thrust *(or other emergency case)*: squawk 7700
- Communication Failure
  - Transmitter Failure; squawk 7600
  - Total Communication Failure; squawk 7600
- Data-Link Loss; squawk 7600
- Communication Failure and Data-Link Loss; squawk 7600
- Transponder Failure *(loss of altitude information)*
- Avoidance of a severe weather *(Thunderstorm)*
- Loss of Separation *(to be defined)*
Evaluation Methods

Subjective Measurements
  • ISA (Instantaneous Self Assessment)

Objective Measurements
  • Time for Communication
  • Others

Questionnaires
  • Post Run Debrief
    • NASA-TLX
    • DFS questionnaire
  • Final Debrief Questionnaire
Simulated Centres

- Frankfurt Arrival (ARR) and Frankfurt Area Control Centre (ACC)
  - west-sector "Langen Radar"
  - radar approach controller "Frankfurt Arrival"
Simulated Airspace

FIR Frankfurt: TMA Frankfurt & Sector West (modified)
Simulated Traffic

Background Traffic:
- Arrivals (26 – 38)
- Departures (0 – 13)
- Overflights (4 – 6)
Simulated Traffic

- Arrival traffic EDDF
- Departure traffic EDDF
- Overflights
- UAV Traffic
  Fixed wing MALE departure from West or North from Frankfurt
  Mission requires crossing of TMA Frankfurt
Simulated MALE UAV

Wing span (m) 22.6
Length (m) 10.68
Normal cruise (kcas) 110
Max. ceiling (ft) 45000
USICO Simulation Room Layout, CWPs

Controller Working Positions

Sector West

Pickup

Supervisor

TC
PC
SV
Pseudo Pilot Working Positions

- Sector West: 1 pseudo pilot
- Sector North: unmanned, dummy traffic
- Sector South: unmanned, dummy traffic
- TMA: 3 pseudo pilots
- additional: UAV pilots
USICO Simulation Room Layout, Pseudo Pilots

Pseudo Pilot Working Positions

PP-WP

UAV Working Positions

UAV

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Simulation Setup

Pseudo Pilots

UAV Pilot (FHS Sim)

Air Traffic Management and Operations Simulator
ATMOS
Simulation Environment

Communication

- Telephone communication between sector controller and arrival controller
- Telephone communication between controller and UAV pilot if requested

Simulated Radio Telephony

- Radio telephony for the controller / pseudo pilot voice communication specially designed intercommunication device operation over wire link
- Communication delay for satellite link is implemented:
  - 1.5 s
## USICO Simulation Runs (Example)

<table>
<thead>
<tr>
<th>Scenario No.</th>
<th>1</th>
</tr>
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<tbody>
<tr>
<td><strong>Name</strong></td>
<td>usico_1_uav_ef</td>
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<tr>
<td><strong>Scenario Description</strong></td>
<td>Engine failure of an UAV</td>
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<tr>
<td><strong>UAV Mission Description</strong></td>
<td>tbd</td>
</tr>
<tr>
<td><strong>Simulation Area</strong></td>
<td>FIR Frankfurt</td>
</tr>
</tbody>
</table>

### Working Positions

#### Controller Working Position
- EDDF, West Sector: 2 controller (TC, PC)
- EDDF, South Sector: dummy
- EDDF, North Sector: dummy
- EDDF, Arrival: 2 controller (TC, PC)
- EDDF, Feeder: not used

#### Pseudo Pilot Working Position
- Normal Aircraft: 4 pseudo pilots
- UAV Traffic: 1 UAV pseudo pilot
### USICO Simulation Runs (Example cont)

**Statistics**
- Total Number of aircraft: 40
  - Arrival aircrafts: 30
  - Overflights: 10
  - UAV: 1

**Percentage**
- **Weight Classes**
  - H: 30 %
  - M: 60 %
  - L: 10 %
- **Sectors**
  - 33 % West
  - 33 % North
  - 33 % South
Let’s start
First Results based on controllers‘s comments

• General
  No special problems with UAV in airspace
  Integration concept allows treatment of UAV like normal aircraft
First Results
based on controllers‘s comments (cont 1)

• Emergency Codes
  7600 for data link loss and comm loss appropriate
  7700 for unpredictable emergency behaviour only
First Results
based on controllers‘s comments (cont 2)

• Telephone comm between controller and UAVpilot is a benefit compared to manned aircraft
Workload of controllers

Week 1

Week 2

2 UASs
Vielen Dank für Ihre Aufmerksamkeit

Fragen?