Integration of UAV into ATC/ATM
Introduction in the simulation demonstration

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Simulation Concept for UAV Integration

Relay

Comm delay

relay C³ link

Avionics System
(NAV / FMS / AFCS / FTS)

C-UAV

Other aircraft

strobe lights

TCAAS II

sense & avoid

VHF COM

SSR transponder

UAV Control Station

Air Traffic Control

Avionics System

relay C³ link

direct C³ link

telephone
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)
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
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

- 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
Controller Working Positions

- Sector West: Langen Radar
- Sector North: dummy
- Sector South: dummy
- TMA: Frankfurt Arrival
USICO Simulation Room Layout, CWPs

Controller Working Positions

- Sector West
- Pickup
- Supervisor
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

UAV Working Positions
Simulation Environment

Based on ATMOS-2-CASS.

Radar

- Horizontal representation of aircraft positions.
- Aircraft labels: callsign, altitude, groundspeed.
- Scale factor, geographical area selected by the controller.
- Optional display items: boundaries, sectors, ATC routes, names of fixes, range rings
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
<table>
<thead>
<tr>
<th>Scenario No.</th>
<th>1</th>
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<tbody>
<tr>
<td>Name</td>
<td>usico_1_uav_ef</td>
</tr>
<tr>
<td>Scenario Description</td>
<td>Engine failure of an UAV</td>
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<tr>
<td>UAV Mission Description</td>
<td>tbd</td>
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<td>Simulation Area</td>
<td>FIR Frankfurt</td>
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<tr>
<td>Working Positions</td>
<td></td>
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<tr>
<td>Controller Working Position</td>
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<tr>
<td>EDDF, West Sector:</td>
<td>2 controller (TC, PC)</td>
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<tr>
<td>EDDF, South Sector</td>
<td>dummy</td>
</tr>
<tr>
<td>EDDF, North Sector</td>
<td>dummy</td>
</tr>
<tr>
<td>EDDF, Arrival</td>
<td>2 controller (TC, PC)</td>
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<tr>
<td>EDDF, Feeder</td>
<td>not used</td>
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<tr>
<td>Pseudo Pilot Working Position</td>
<td></td>
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<tr>
<td>Normal Aircraft</td>
<td>4 pseudo pilots</td>
</tr>
<tr>
<td>UAV Traffic</td>
<td>1 UAV pseudo pilot</td>
</tr>
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</table>
USICO Simulation Runs (Example cont)

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

**Percentage**

<table>
<thead>
<tr>
<th>Weight Classes</th>
<th>Sectors</th>
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<tbody>
<tr>
<td>H 30 %,</td>
<td>33 % West</td>
</tr>
<tr>
<td>M 60 %,</td>
<td>33 % North</td>
</tr>
<tr>
<td>L 10 %</td>
<td>33 % South</td>
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</table>
Let’s start
Demonstrations

Three Groups: G1, G2, G3

• ATM/ATC integration, Emergency procedures
• Collision Avoidance System
• Enhanced Vision Systems

All groups will see everything

Now: Lunch
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
Simulated Airspace

- FIR Frankfurt:
  - Sector West (modified)
  - TMA Frankfurt
Simulated Airports

USICO will simulate the approach traffic of Frankfurt (and Hahn or another potential UAV airfield)
Simulation Concept for UAV Integration

Relay

C-UAV

UAV Control Station

Air Traffic Control
Simulation Concept for UAV Integration

UAV Control Station

Air Traffic Control