Technologies for Autonomous Operations of UAV’s

- Motivation for Autonomy
- Autonomy – Status Quo
- Sense & Avoid
- Way Ahead
Motivation for Autonomy

• Operational effectiveness of UAVs strongly influenced by degree of (on-board) autonomy

• Core of autonomy is capability to:
  – perceive vehicle-internal system state and external environment
  – assess the perceptions
  – make decisions in order to reach pre-determined goals

• State of the art:
  – human pilot with many sensors (vibration, smell, sound, look & feel)

• Operator on ground not capable to take pilot’s role in case of
  – non-availability of data-link
  – time-critical decisions…..

Take the pilot out of the aircraft ..
.. without loosing his capabilities!
Autonomy Road Map

Autonomous capabilities of UAS

- Fully Autonomous Swarms
- Group Strategic Goals
- Distributed Control
- Group Tactical Goals
- Group Tactical Replan
- Group Coordination
- Onboard Route Replan
- Adapt to Failures & Flight Conditions
- Real Time Health/Diagnosis
- Remotely Guided

Source: Unmanned Aircraft Systems Roadmap, US DoD, 2005

*FCAS = Future Combat Air System
Operational Scenario drives Mission Autonomy

UAV - MALE

- All weather target detection and identification
- Operational Altitude > 40 kft
- Weaponised Male
- Autonomous mission execution

FCAS

- All weather target detection and identification and attack
- High threat scenarios
- Joint mission execution
Autonomous Operations - Enablers

- Secure safe unmanned flight
- Automatic Target Detection, Recognition and Identification
- Change detection for detection of moving targets
- Tracking and Geo-referencing
- Sensor Fusion
- Onboard near Real-time Sensor Exploitation
- Sensor steering and queuing (platform steers sensor)
- Sensor slaved modes (sensor steers platform)
- Communication with other platforms
- Execution of ISR and FCAS missions

How much autonomous behaviour is required / permissible?
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Barracuda is the EADS UAV Technology Demonstrator for ..

- unmanned flying
- Talarion and FCAS Scenarios
- Agile UAV in Network Centric Environment
  (German MOD Contract)
Barracuda

- Demonstrator size close to operational UAV
- Fully autonomous operation / no remote control
- Conventional T/O and landing
- Robust flight guidance and flight control
- Fully electric A/C in flight
  - electromechanical actuation
  - electrically operated carbon brakes
- Structures:
  - High-tech carbon fibre in a highly integrated production technique
  - Components manufactured using EADS developed Vacuum Assisted Process (VAP) technology
  - Pluggable wing (modular concept)
- Avionics:
  - Triplex FCS / NAV
  - DGPS w/SBAS supported NAV / independent of any ground infrastructure
  - STANAG 4586 standardized interfaces (open modular architecture)
Barracuda - Basic Unmanned Flying

• Fully autonomous system:
  – pilot in command has to push the “Start” button, and
  – after mission execution and auto landing, the “Engine shut down” command.

• No additional interactions are required.

• To react on contingencies, the system and the operator can interfere via High Level Commands (e.g. Go-Home, turn around, mission abort, new waypoint(s)).

• Barracuda will accept High Level commands as long as the Save Flight State is not violated.

• Situational awareness for the Pilot in Command via permanent status reporting (STANAG 4586 command/status messages)

• Auto-start and auto landing is based on EGNOS wide area augmentation system. No manual landing is implemented.

• Flight safety is secured by a triplex redundant system architecture
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Sense & Avoid – Situation Today

➢ “Sense & Avoid” is considered the primary restriction to normal operation of UAS

➢ UAS without S&A capability may be restricted to certain routes, confined to specified airspace, and restricted to altitudes that do not provide maximum operational flexibility

➢ Achievement of the S&A capability is therefore a key enabler for UAV operations

➢ Regulation and Standardisation are considered as “Door Opener”, but require an increased effort

Initiatives

Air4All

MidCAS
### Air4All – UAV Airspace Integration

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<th>Step</th>
<th>IFR</th>
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<td>Step 1</td>
<td>Fly experimental UAS within national borders in segregated airspace (regular, at short timescale) – Unpopulated range</td>
<td>Fly a national type certified state UAS as IFR traffic within national borders, routinely in controlled airspace (airspace classes A, B, C)</td>
<td>Fly an experimental UAS as IFR traffic within national borders in controlled, non-segregated airspace (airspace classes A, B, C)</td>
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<tr>
<td>Step 1a</td>
<td>Fly experimental UAS within nat. borders in segregated airspace (regular, at short timescale) - overflown sparse population</td>
<td>Fly a civil type certified UAS as IFR traffic within national borders, routinely in controlled airspace (airspace classes A, B, C)</td>
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**Experimental UAVs**

- Fly a civil or state UAS as IFR traffic across national borders, routinely in non-controlled airspace (airspace classes A, B, C, D, E, F, G)

**National Operations**

- Fly a state UAS as IFR and VFR traffic across national borders, routinely in non-controlled airspace (airspace classes A, B, C, D, E, F, G)

**International Operations**

- Fly a state UAS as IFR and VFR traffic across national borders, routinely in non-controlled airspace (airspace classes A, B, C, D, E, F, G)

### Timeline

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**Military UAV market entry point**
Air4All – Identified Challenges

- Aircraft Separation (including consideration of future ATM)
- Collision avoidance (including future ATM)
- Secure and sustainable communications for command and control
- Air Traffic Control interface
- Radio bandwidth allocation
- Dependable emergency recovery
- Health monitoring/Fault detection
- Automatic take-off and landing
- Automatic taxiing
- Autonomous behaviour
- Weather detection and protection
- Harmonised military Type Certification process (manned and UAS)
- Agree rules and regulations with Authorities
- UAS pilot/commander training
- Security of Ground Station
- Public acceptance
MidCAS Objectives

- To design the architecture of the future UAV/UCAV S&A system able to fulfill the requirements for traffic separation and mid air collision avoidance in non segregated air space.
- To contribute to standardization effort such that standards and solutions progress in parallel.
- To build up system architecture and performance on simulation correlated with flight results.
- To achieve and demonstrate the technical capability that enables operations in all airspace classes with the same degree of access as manned aircraft.
- To demonstrate the safety level relative to mid air collision using simulation.
- To demonstrate system performance on a real UAV (Alenia Sky-Y).
MidCAS vs. Standardisation & Certification Process

MidCAS

Main stakeholders
CAAs
pilots associations
Airlines, Aerospace Industry...

Directive 98/34/EC
coordination

Ops rules, regs, stds
AMC for ESARRs
Tech standards, MASP, MOPS
ED docs for ETSO

pMS

ED docs for ETSO

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Way Ahead

Autonomy for UAVs

.. through joint effort in ..

- Research & Technology
- Demonstrations
- Standardisation