Application of Robotics and AI Technologies to the Future ATM

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Outline

• Motivation

• Automation of ATM
  – Methods for trajectory planning and conflict resolution
  – Fully automated airfield

• ATM and Unmanned Aerial Systems

• Integration of RPAS into the non segregated Aerial Space

• Conclusions
MOTIVATION

- European ATM Master Plan
  - Goal: Towards Higher Levels of Automation in ATM

- What does Automation in ATM encompass?
  - Decision Support Tools
  - Performance Based Navigation
  - Conflict Detection & Resolution
  - Management of 4D trajectories and trajectory prediction
AUTOMATION OF ATM
Methods for trajectory planning, collision detection and resolution

• Collision –free trajectory generation

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AUTOMATION OF ATM
Methods for trajectory planning, collision detection and resolution

- Classical search
  - Dijkstra
  - A*, D*, θ*
- Probabilistic
  - RRT, RRT*, PRM
- Optimization
  - Genetic algorithms
  - Particle Swarm
  - Ant Colony
  - Potential fields (local)
- Optimal Control
  - Collocation or Pseudospectral Methods
  - MILP
  - Dynamic Programming
AUTOMATION OF ATM

PLANET (FP7): Fully automated airfield

Airfield management system

– Time slots
– Safety functions: Integration of surveillance radar, meteo station, ground obstacle detection, positioning
– Fully autonomous parking, taxi, take-off and landing
– Emergency management (ATC Failure) with aircraft autonomous negotiation
– Sensor network for surveillance
– Communication Security

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ATM and UAS

**SESAR**
- ATM
- Detect and avoid
- Separation assurance
- 4D Trajectory management
- Integration into non-segregated aerial space

**Unmanned Aerial Systems**
- Planning
  - Mission planning
  - Task Planning
  - Trajectory planning
- Environment Perception
  - Mapping, Localisation
- Autonomous system design

**Supervised autonomy**
- Required to increase safety
- Coordination

**Higher autonomy**
- Minimal requirements
- Cooperation (air-air, air-ground-sea)

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ATM and UAS

- Planning safe and efficient trajectories with dense traffic and ground obstacles
- Reactivity for sense and avoid
- Fully autonomous landing in difficult conditions
- Sensors and Perception for navigation at low altitude and landing without global positioning
- Functionalities for human assistance (Tele-robotics)
- Surface operations
- Tools for autonomous system design

- Possibility to integrate aerial robots (RPAS) in airspaces (regulations and certification)
- Standards and procedures
- Safety measures
- Reliable communications
- Security: cyber threats

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Integration of RPAS in non-segregated airspace

Project scope and objectives

- ARIADNA (Activities on RPAS Integration Assistance and Demonstration for operations in Non-segregated Airspace) is oriented to the integration of RPAS into the aviation system (including the ATM system).

- Consortium: INDRA, ENAIRE, FADA-CATEC and CRIDA
Project scope and objectives

**Exercise 1:** SBAS-based approach and landing procedures applicable to RW RPAS

Main objective: demonstrate the feasibility of adapting a navigation procedure from (manned) helicopter "SBAS-based approach" (PinS) to a RPAS

Low performances (speed and rate of descend) Manageable in low density and complexity airports.

**Exercise 2:** Concepts for a ground-based situational awareness system (GBSAS) that can be integrated in a RPAS

Main objective: Use of ADS-B technology data (current surveillance technology) to provide remote pilots with improved situational awareness of surrounding traffic (plus safety backup in case of C2 link loss)

Situational awareness maintained

RPAS requires more attention: Stress

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Introduction

Video

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Experimentation facilities

• Indoor
  – Testbed 16x15x6 m
  – VICON System
  – Able to fly more than 10 vehicles at the same time

• ATLAS RPAS Experimentation facility
  – Segregated aerial space: 35 x 30 Km, Altitude: up to 5000 ft
  – Main runway: 800m x 18m
  – Auxiliary sand runway: 400m x 15m
  – Control center for mission operations
  – Independent Hangars for different customers
  – Logistic and Technical support
Conclusions

- Automation can benefit from developed techniques in artificial intelligence and robotics (applications with multiple aerial vehicles)
- Efficient implementation of trajectory planning/generation
- Current challenge: Integration of RPAS in non-segregated airspace:
  - Increase safety
  - Emergency landing
  - Fault detection and reconfiguration
  - More reliable detect and avoid
  - New communication and security paradigms
  - Technologies for long term missions