Future cargo aircraft and small passenger planes: Will they fly autonomous?

Ad de Graaff, AD Cuenta Twente, February 2014
ACARE Strategic Research and Innovation Agenda

• Since 2002 the European civil aviation stakeholders (united in ACARE) publish a strategic agenda

• In the last version (2011) it is assumed that cargo planes will be the first to fly fully autonomous before 2050
Contents

• Short history
• What is autonomous flight
• Case study 1: Future cargo aircraft
• Case study 2: The small aircraft market
• Technology, certification, security and liability
• Need for research
Short history UAS

• The military have a long experience with remotely piloted vehicles (line of sight)
• Some UAS fly a pre-programmed (part of the) mission

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Line of sight control

- Line of sight control can be via direct data link (up to 150 nm) or via satellite/airborne relay
- Systems require a human operator to “fly” the RPAS, who is responsible for avoiding collisions with the ground, obstacles and other aerial vehicles
Line of sight is not always successful
Civil use of unmanned aircraft

- Civil use of unmanned air vehicles is still limited due to airspace restrictions (visual line of sight, altitude, segregated airspace)
- Amazon has certainly helped to speed up the discussion on the use of civil UAS
Autonomous flight?

• First application of “autonomous” flight was in 1849 when the Austrians used unmanned balloons to bomb Venice. A total disaster.

• Since then autonomous flight has been a dream

• What is it, do we need it?
Autonomous flight

• A flight executed by a device able to perform complete complex flying missions safely and very efficiently without human interference.

• Such a system will perform all pilot functions (flying, navigation, emergency control, hazard mitigation, collision avoidance) including communication with other air transport system elements.
Why is autonomous flight important

- If autonomous flight could be safe and use sense and avoid in the airspace for separation there is a substantial cost benefit as there is no need for
  - Segregated airspace
  - Pilots
  - ATC controllers
2 cases for possible applications of autonomous flight:
Future cargo aircraft and small passenger aircraft
Different types of operators:

1. All Cargo Carriers operate all cargo aircraft (e.g. Cargolux)
2. Combination carriers with dedicated cargo business (e.g. AF/KLM, Lufthansa)
3. Passenger airlines with belly freight
4. Integrators (DHL, FedEx etc)

Note: LCC do not carry cargo (turn around time, destinations, profit)
Case 1: future cargo aircraft (2)

Air freight commodities

- Air freight remains for transport of time-sensitive commodities
- Types of goods:
  - high-value, low-weight goods including consumer electronics
  - high-value intermediate goods
  - fashion
  - pharmaceuticals
  - industrial machinery
  - perishables
Case 1: Future cargo aircraft (3)

- Air cargo demand has suffered from the recent economic crisis
- Cargo is transported by dedicated cargo aircraft or as belly freight
- Belly freight sets the price
- Load factors on dedicated cargo aircraft is low
Case 1: Future cargo aircraft (4)

- Air cargo is confronted with increased competition from sea and surface transport
- E-freight is not well implemented
- The sector is in a surviving mode: *no out of the box thinking*
Case 1: Future cargo aircraft (5)

- About 10 years ago Airbus was thinking about unmanned cargo aircraft to serve the European economy better.
Case 1: Future cargo aircraft (6)

- The recent EU project CARGOMAP looked into long term developments.
- Based on criteria *Time, Frequency and Cost* as well as *Environmental impact*, it proposed 4 types of new cargo planes for the 2050 timeframe.
Case 1: Future cargo aircraft (7)

- To be competitive and achieve low Direct Operating Cost, all designs would fly autonomous.
- Cargo handling will be fully robotized.

No crew in the aircraft or on the ground.

- No pressurized cabin means very low production cost.
- A simple fuselage means less parts and low maintenance cost.
- Less weight means lower fuel cost.

Low cost for ATC and surface movement.

- Pilot Salaries 19.1%
- Other Flying Operations 10.5%
- Aircraft Fuels 30.8%
- Labor for Airframes 3.3%
- Labor for Engines 0.9%
- Airframe Materials 3.0%
- Engine Materials 2.8%
- Other Direct Maintenance 5.5%
- Insurance 0.4%
- Depreciation 7.8%
- Amortization (Rentals and Capital Leases) 15.8%
Case 2: Small aircraft

- The EU funded SAT-Roadmap study investigated the use of small aircraft to partially replace road transport for
  - personal travel (Air Taxi) and
  - Public Service Obligations in Europe
Case 2: Small aircraft (2)

Some studies suggest that the number of cars in the world will increase from around 700 milion today to more than 3 bilion in 2050...

Communication from the EC 17 June 2009

This calls for a modal shift!
Case 2: Small aircraft (3)

- The study took into account
  - the extension of the European High Speed rail network (partially funded by the European Commission via TEN-T projects) and
  - the availability of 2500 airports and aerodromes in Europe

For most European cities, the nearest airport or landing field is located within 15 km (90% of cities)
Case 2: Small aircraft (4)

- Based on an extensive analysis, the study showed a large potential demand for small aircraft operations in Europe.
Case 2: Small aircraft (5)

To satisfy demand there would be a need to:

• Transport 61 million passengers per year

• Allow **43 million air movements** per year

• Use **54,000 aircraft** assuming a 1,000 hour annual utilization
Case 2: Small aircraft (6)

- It is obvious that even with single pilot operations or remote control the number of pilots required would exceed the possibilities.
- Here autonomous flying is a must in the future.
Can we achieve autonomous flight?
Technologies for autonomous flight

• To fly safely the aircraft needs to know
  – where it is,
  – where it wants to go and
  – where other aircraft and hazards are

• Vehicles will use the existing means like automated take-off, -cruise, -landing, GPWS, TCAS, data links etc. if applicable

• Sense and avoid systems and algorithms are needed, data fusion based on GNSS data in combination with IT networks (SWIM) and transponders (ADS-B)

• If no GNSS is available inertial navigation and laser rangefinders are an option
Technologies for autonomous flight (2)

- Intelligent computer systems need to negotiate timing of slots in the air and at busy airports to optimize capacity (automated CDM)
- Re liability of computer hardware and software is currently too low
- Current SESAR predictions on equipment cost exceed all possibilities. Therefore systems need to be *small, reliable and very low cost* with high performance
Certification

- Autonomous flight in regular airspace is not allowed as no reliable sense and avoid systems with adequate performance exist
- The restricted use of segregated airspace is of no interest to commercial operations
- Development and testing of autonomous guidance systems and certification should go hand in hand to ensure confidence and fast certification based on confidence
Security and Liability

- Security issues like the hacking of data links should be a **design parameter** in the development of autonomous flying.
- Liability issues need early attention so that these will not become a showstopper in future.
Research!

- In order to enable fully autonomous flight before 2050, research efforts need to be stepped up.
- We need to do more research **now** to prepare for the future, even if some do not believe in the concept.

Think different!
Thank you for your attention

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