Since the Second World War, Unmanned Aircraft Systems – UAS - have been designed and used for military missions. Over the last years, the UAS industry has made significant operational and technological progress worldwide. These advanced UAS technologies offer a wide range of potential civil applications such as support of search and rescue activities, environmental surveillance, pollution detection, weather monitoring, fire monitoring, mapping, coastal and border surveillance and control, surveillance of infra-structural facilities (pipelines, airports, railways, roads, waterways, etc.) and airborne telecommunication relay-station.

Recent development and experimentation have shown that UAS technologies have now reached a remarkable level of maturity. European UAS manufacturers are now pursuing opportunities to demonstrate and assess the ability of UAS to operate in non segregated airspace making UAS certification paramount for safety and security. This shows that the emerging civilian UAS applications will become reality in the next decade and ATM will be able to support this new type of traffic operating with all other airspace users. EUROCONTROL in collaboration with other regulatory bodies (such as ICAO, EUROCAE, EASA, EC, FAA and NATO) is already acting in proposing regulatory policy to support UAS development. The Single European Sky through the SES ATM Research Programme (SESAR) is defining the next generation of the ATM system to cope with the traffic growth. This new ATM concept will enable UAS to be integrated in the ATM of the future.

To support these activities, the EUROCONTROL Experimental Centre proposes to develop a twofold UAS research programme:
- the first research area is in the area of providing support for assessing the integration of UAS in non-segregated airspace in the context of the current and future ATM system; and
- the second research axis concerns investigating the potential of transferring Detect, Sense & Avoid technologies or any other kind of emerging UAS technology into the future automated Air Traffic Management system.

The EUROCONTROL Experimental Centre

EUROCONTROL, the European Organisation for the Safety of Air Navigation, is an intergovernmental Agency of currently 37 Member States and the European Community. The Agency’s mission is ‘to harmonise and integrate air navigation services in Europe, aiming at the creation of a uniform air traffic management system for civil and military users, in order to achieve the safe, secure, orderly, expeditious and economic flow of traffic throughout Europe, while minimising adverse environmental impact’.

The Agency’s business strategy and activities are fully committed to supporting the implementation of the Single European Sky and the SESAR programme.

The EUROCONTROL Experimental Centre (EEC) is an integral part of the EUROCONTROL Agency in charge of the technical management of Agency research. EEC orientations are derived from the EUROCONTROL Agency’s strategy as established in our Agency Business Plan.

UAS Today

Last year UVS International in «The Global Perspective 2006/2007» edition, listed 604 UAS models either produced or under production, by more than 250 manufacturers over more than 40 countries worldwide (Europe, North & South America, Middle East, Asia). Even if the list provided was not complete, it illustrates the large amount and diversity of UAS already flying or about to fly in international skies.

UAS today range from Micro UAS, with a maximum take off weight (MTOW) of less than 10Kg, flying less than 1 hour at very low altitude (up to 250m) over less than 10nm; to High Altitude Long Endurance UAS (HALE), with MTOW in the order of tons, flying up to 48 hours at high altitude (up to FL600) over more than 1500 nm. UAS projects exist for developing stratospheric or exo-stratospheric UAS flying very long range and very high altitude (greater than FL600). UAS are rotary or fixed wings (very few are flapping wings); remotely piloted or fully autonomous or both; piston, turbo prop, turbine, jet, electric or solar powered. One of the smallest UAS in the world is from Norway with the Proxflyer, an ultra micro UAS which MTOW is about 3 grams. One of the heaviest UAS is from USA with the X-45C, an Unmanned Combat Aerial Vehicle with a MTOW of appr. 16.5 tons. Most UAS are still under development. Most of them are for military purposes. But today, more than 100 UAS are already being directed at the civil/commercial market.

UAS can be flown by either remote control (operator input provided from a UAS ground control station) or in full autonomous mode (not controlled from any ground station). In most cases, for autonomous UAS, it is always possible to redirect control back to a remote ground station in case of emergency. Autonomy of the UAS is also based on various technologies. The «easiest» one is to hardcode behaviour and reaction rules in the machine piloting process. More advanced systems are now emerging allowing the UAS to learn and adapt its behaviour based on information gained from the external environment.

This list, again not exhaustive, gives the very high diversity of UAS which could fly in non segregated airspace tomorrow. It opens also the large spectrum of technologies developed to help develop such UAS which will fly safely.

UAS Challenges/Opportunities to ATM

Primarily designed to operate in segregated airspace, excluding any interaction with manned aircraft, the emerging civilian UAS missions will require UAS to operate in non-segregated airspace alongside all other airspace users. This new challenge calls for a technological revolution allowing UAS to fly safely and including autonomous mode with the ability of avoiding any collision with any other kind of manned or unmanned flying object or with any kind of ground infrastructure. Detect, Sense and Avoid applications will be the corner stone of such future UAS operating in all classes of airspace. The principle UAS airspace requirement established by EUROCONTROL and its Airspace Domain stakeholders is for UAS operating in non-segregated
airspace to achieve ATM transparency: meaning that UAS shall be operated like manned aircraft. It is also understood that the evolution of UAS systems will provide opportunity to improve ATM for the benefit of all users and in this regard it is expected that ATM transparency will apply to the ATM environment as it evolves, an evolution which UAS are in a position to influence. Several organisations/projects are already developing provision for UAS integration in non-segregated airspace (ICAO, SESAR, EUROCAE WG 73 (being led by EUROCONTROL), EASA, SES, RTCA, FAA, and NATO for example). In parallel, UAS manufacturers are developing UAS mission requirements. This will result in the development of a UAS road map which will describe the research activities to be performed to allow UAS operations in non segregated airspace. Nevertheless, integrating UAS non-segregated airspace will both challenge and provide opportunity for the ATM system of the future.

The high diversity of UAS applications and operating modes (missions) may increase the air traffic complexity. Specific solutions will have to be addressed to consider the wider spread of UAS user characteristics and preferences. Also, ATM and UAS communities shall review to which extend the UAS shall comply with ATM capabilities versus how far the predictive and performance driven ATM can comply with autonomous aircraft capabilities.

The wide range of UAS (size and performance) to be integrated in the mix of civil/military air traffic raises concerns such as safety (situation awareness, separation minima, collision avoidance systems, flight dynamics), surveillance and trajectory prediction (positioning, communication means within ATM system architecture, cooperative issues), Inter-operability (integration of collision avoidance application, positioning, communication means within the ATM system architecture cooperative issues), predictability (scheduling, sequencing, trajectory negotiation), security (communication and remote control), automation and reliability.

The UAS manufacturing community is somewhat fragmented and will require a common UAS/ATM interface definition.

Assessing UAS Integrated in ATM

In order to assess the UAS integration in non-segregated airspace, several validation activities shall be performed ranging from model based experimentation to human in the loop and ATM system wise simulation. Models shall be developed based on mission requirements and associated concepts of operation. Close cooperation with UAS manufacturers and operators together with regulators will be required. These models will aim at identifying areas where either the current ATM system and regulations are lacking, or where UAS performance is lacking when addressing issues of UAS flying in non segregated airspace. Therefore, these models shall be designed in the context of the current ATM system, but shall also be derived to assess the UAS concept of operation in the future ATM system. These models will address the issues of safety, security, automation, reliability and inter-operability.

Output of the model based validation shall then be refined and confirmed through human in the loop simulations. These simulations shall assess in pseudo real time conditions the impact of UAS operations in non-segregated airspace. Focus shall be given to human factors and interoperability issues. Again, close cooperation with industry will be needed especially in the development of UAS simulators or emulators that would be linked to existing real time simulation platforms. It seems obvious that UAS won’t fly directly in non-segregated airspace, but would first be operated in intermediate airspace (non-fully integrated) with general aviation but not flying in isolation in a secured and isolated airspace bubble. Transition scenarios will have to be defined. We could imagine that airspace design will be a key issue in this transition. Therefore, novel airspace design processes may need to be developed to accommodate an initial integration of UAS in ATM. Flexible use of airspace could be a promising path for having the first UAS operated in the ATM with specific regulations. Transition scenarios would also be a perfect tool for demonstrating and increasing the reliability of the UAS as it should give the opportunity to the UAS manufacturers to assess the UAS technologies in conditions closed to the full integration with ATM. It will be also an efficient and pragmatic way of refining and developing the regulations/rules in parallel with progress made by industry. This would allow everybody, manufacturers and regulators to have a stepwise approach instead of having a big bang.

UAS Technologies vs Future ATM Automation

When flying an aircraft, the pilot has the main responsibility of flying to a given destination in a safe and efficient manner. Safety is the paramount of aviation. All the elements of the Air Traffic Management system are designed for the safe, efficient and expeditious management of the traffic. But, the pilot bears the ultimate responsibility of assuming the safety of his/her flight. Information about the surrounding environment (other traffic but also ground infrastructures) is provided by many electronic means. But, except for TCAS which gives instruction to the pilot in emergency cases, none of these technologies make any decisions; they only support the pilot in his/her decision making process. The main characteristic of the pilot is his/her ability to make rapid decisions in very complex and stressful situations especially in cases of collision risk. These decisions are based on information provided by technologies but also with information gained via his/her ability to see and to «feel» the situation. By definition, a UAS is not manned. So, new technologies are required to provide UAS with the ability to detect, to sense and to avoid, in order to fly safely and efficiently. Initial Detect. Sense and Avoid technologies have already been developed for both cooperative and non cooperative modes.

This will provide a very advanced level of autonomy for the UAS. Of course, till today, certification of these technologies is an open question, but we trust that tomorrow, we will be able to achieve an acceptable certification for them. Thus, one day, the ATM will be composed of a mix of manned aircraft and fully autonomous ones flying safely together. UAS will perform self separation with other UAS but also with manned aircraft. As, at the same time, we could expect that separation keeping would have been transferred from the ground to the air, we could imagine to fully automate the aircraft airborne separation for both manned and unmanned aircrafts. And so, part of the Innovative Future Air Transport System (IFATS) dream, the pilot less system, would become reality. UAS non cooperative self separation technologies could be a path to move from the current ATM system to a more automated one; where all aircrafts would not be fully automated.

In that context, the role of the Air Traffic Controller (ATCo) in an automated ATM could focus more on the ATM resources management such as flow management (opening, closing flow, flow timing management), airspace management (opening, closing flexible airspace areas). Safety management will nevertheless remain under the control of the ATCo with the ability of the human being for solving highly complex situation or finding quick solution in case of system mal-function. The future ATM system might become more
cooperative with the ability of self learning and adapting its global behaviour from information provided by all the actors (human being and system).

Detect, Sense and Avoid technologies would also require high accuracy of sensing and positioning information; and trajectory prediction. These evolutions could also be used for classical aircraft. This done, we could expect getting more accurate data in the overall ATM system which, then, would increase the predictability of the system. Very accurate 4D profile based system might then become a reality.

Another potential opportunity of getting UAS technologies integrated into the future ATM is about the UAS ability of being remote piloted. Some UAS are fully autonomous, meaning that no pilot operates the application from the ground. Notwithstanding that certification is again a key element to address, we could imagine these remote piloting technologies to be also used for manned aircraft when there would be a need to get the flight control back to the ground for security reasons for example. This could be another revolution for manned aircrafts and would be a way of increasing the security level of the ATM of the future.

Conclusion

UAS developments and perspectives are challenging the ATM of the future. Considering the pace of technologies progress, UAS will be requiring to operate in non segregated airspace in a near future. The next ATM concept under development by the SESAR programme is already considering the UAS, but huge and careful validation is required.

UAS technologies are also opening opportunities for more advanced control means and automation. Long term research might be developed in order to investigate how UAS technologies might be re-used to design and develop a highly automated ATM system which could be the next generation of ATM system after the SESAR’s one, meaning at the horizon of 2050?