Cockpit automation in the context of a global AGS system (by Michel Masson)

The expected developments of cockpit automation must not be considered as standalone. They will take place in the context of a new, global and integrated Air, Ground & Space AGS system. This new system can be considered as a *"distributed multi-agent system"* in which the various agents, both human (the different personnel, flight crew, ATC/ATM, etc.) and artificial (the automated systems) communicate (for instance through data-links), interact and co-operate.

Cockpit automation shouldn't therefore be considered in isolation but on the contrary in relation to the rest of the global AGS system. A good example is Fully Automated Flight (FAF), which can be considered an extreme of cockpit automation. Should FAF come true in the future, no doubt that it will directly or indirectly affect the other agents of the global airspace system. Regarding FAF, the most realistic hypothesis that has been envisaged within this FAST project is that it will require ground-based Strategic Command and Control (SCC) centres combining remote monitoring and control, ATM/ATC and airline and operations.

Beside FAF, functions and structures that today appear separated will become more and more inter-related or inter-dependent in the new airspace paradigm.

INTRODUCTION (by JP Magny)

The following present a synthesis of FAST Outcomes with the intention to provide a **Vision of the Aviation Automation Future**.
Time frame expressed in terms of decades is meant to be 20 years +/- 10 years.

It must be kept in mind that major technological changes affect primarily new materials (New Aircraft, New ATC systems) together with a progressive but slow update of older inducing a permanent co-existence of vintage and of newer technologies.

The document doesn't intend to replace the list of AOC in cutting and pasting AOC list. The purpose is to:

- View the world of Aviation Changes from higher altitude to improve people's perception.
- Draw the attention on specific points of concern arising from a global view.
- Highlights the insidious effect of permanent transition phenomena resulting from long co habitation phases.

The document contains 6 categories of Changes, those concerning:

1. Aircraft and directly interfaced HW, SW, LW,
2. ATC/ATM alone
3. Both ATC and ACFT
4. Industry
5. Populations and Cultures
6. Others

1. **Aircraft and directly interfaced HW, SW, LW,**

Most Changes concern:

- New features for improving performances and ACFT handling Characteristics (e.g. Fly by wire / light controls)
- ACFT Systems management (FADEC, Fuel Management, Power Management etc.).
- Navigation and Situation Awareness
- Aircraft Maintenance
- Databases moving from some sheets of papers to 3D terrain DB and more.

All these changes have common Characteristics:

- Transfer of functions from Crew to Systems:
- Intended and more generally achieved Safety Enhancements
- Complexity of Systems Functions and Artificial Intelligence make difficult a complete understanding of what the system is doing. That's requiring to establish clearly a boundary between Systems for which Human Back up / override is intended / possible, e.g. fuel management, braking System etc) and those it is not (e.g. FADEC, unstable flown by wire ACFT).

Major effects:

- Requiring much less Workload and Skills in Standard Operations but:
    - Possibly requiring more attention and Skills in emergency situations
    - Lowering probability of Emergencies requiring specific Skills may induce a tendency for reduced training / proficiency.
- Tendency of shifting responsibilities from humans to Systems
- Creating a deep sensation of comfort and a feeling of incident free operations contrasting with sudden panic when Systems behaviour is not understood and is not doing what was expected.
- Changes affect deeply Operators (Flight and ground Crews) culture and background.
- Reverting from NEW to OLDER Systems / ACFT raises serious questions that may not be taken seriously therefore not well analysed.

2. **ATC/ATM specific**

Most Changes concern:

- New concepts of Airspace Management associating:
    - New Ground and Space Systems:
        - Navigation
        - Communication
        - Surveillance
        - Computers
    - New procedures:
        - En route
        - TMA
        - IAL

Major effects

- ATC Controllers relying more on computers and alert Systems that may create:
  - Loss of situation awareness (like for pilots)
  - Difficulty to understand what systems are doing
  - Difficulty to be fully aware of real performances of the Systems and to performance changes in degraded modes;
- Using ATC improved performance for increasing traffic density / lowering separation Standards:
  - More reliance on computers decreases the possibility for man to hand over emergency cases;
  - Heterogeneity in Airspace Categories and practices may create interface weaknesses that are seriously weakening computers performance. Phenomena may be not fully evaluated and some insidious weaknesses not rose to consciousness.
  - Lack of continuity in Airspace interfaces forces ATC to revert to last minute route changes, using old-fashioned practices.

3. Both ATC and ACFT

Above mentioned changes are affecting also ACFT and ATC interfaces in particular:

- Share of separation assurance responsibilities between Air and Ground, making corresponding coordination of paramount importance. This coordination has to be established with more robust basis / management than in the past. It shall address:
  - Systems design right from concept to operations
  - Crew procedures
  - Various configurations of older and recent systems with corresponding ATC and Pilots procedures.
- Emergence of communication means progressively permitting direct communication between ATC and ACFT Systems.
- On board Databases contain data from ATC, Terrain, ACFT whose production involves various actors that together must ensure Integrity.
- Emergence of new navigation Systems supporting new separation standards and new procedures, but:
  - Adverse effects such, as consequences of increased navigation accuracy have to be assessed to redefine routing and procedures. (e.g. vertical error when new navigation systems have zeroed lateral separation)..
  - Mix up of various on-board and ground systems with functions dedicated to collision avoidance may induce conflicts that must be sorted out.
- Further possibility to allow ground computers to interact with Airborne Systems with direct effect on Aircraft route is in view. This possibility raises questions of:
  - Crew awareness of Systems behaviour
  - Responsibility issues between ground crew, ground systems, flight crew, flight automation and associated psychological issues etc…

  But paves the way to fully automated flight and the huge amount of problems, including cohabitation with manned flights.

4. Industry

Is facing mainly:

- Technological changes for which Engineering practices to create and to certify new systems are mature within major ACFT designers organisations but may be seriously affected by other changes.
- A continuous tendency to involve more and more Industry Partners of various nations, therefore to create more and more complex organisations.
- Both families of Changes interact and may induce:
    - Coordination difficulties within organisations.
    - Communication flaw affecting partners not working together previously or having different culture.
    - Engineering problems in particular when right from concept phase, an On Board system must be developed in the frame of Aircraft architecture (e.g. FMS).
    - Production coordination
    - Incident treatment weaknesses
    - Dilution of responsibilities making people less responsible.
- New challenge brought by more stringent Safety Objectives affect deeply mentalities and procedures. Consciousness of the phenomena is not obvious.

5. Populations and Cultures

Aviation is made of top-level technology changes and older systems survival.
Many Airliners are flown and maintained by people that were not born when the airliners were produced.
On the other hand, some senior personnel may feel reluctant to entirely trust new systems that were not part of their basic culture.
Turn over of personnel, involvement of more subcontractors and of people of various nationalities, schools and training program changes may be well adapted to new generations of Systems but may be less to older ones.

We do not pretend to identify all possible consequences and fixes but simply propose to highlight that everything is changing in the Aviation World, even in older generation of Systems and we shall insist for a specific survey and analysis of any change.

6. Others

Significant Hazards may be generated by Interactions between changes.

Certifications authorities have to cope with:

- Interfaces between Systems (e.g. ATC – ACFT)
- Interactions between changes
- Survey of continuous but possibly insidious changes.
- Co existence of various generations of Systems, both Ground and On Board.
- Changing organisations that probably will require authorities to look more at organisations and processes.

Why further developments in the domain of cockpit automation? (by Michel Masson)

The developments of cockpit automation serve the main objective of increasing airspace capacity by increasing navigation accuracy and by supporting the transfer of some of the control functions currently performed by the ATM/ATC to the flight crews.

Cockpit automation also improves flight performance and increases economy by decreasing operation and maintenance costs.

Automation is also a means of improving *safety*, and this by different ways, i.e.:

- By reducing the likelihood of CFIT and ALAR accidents through new or improved terrain recognition, traffic avoidance and navigational aids, and their integration.
- By enhancing the crew awareness of the external environment, e.g. taxiway (ground), terrain (low altitude), traffic (air and ground), airways, weather, navigation path, threats and communication through improved situation awareness (SA) means (displays, visual, auditory and tactile signals and alerts).
- By enhancing the crew awareness of the automation functions, status, modes and behaviour (both airborne and on the ground).
- By enhancing the awareness of the global AGS distributed multi-agents control, command and management system to all personnel concerned: flight crew, cabin crew, ATM/ATC staff and maintenance personnel, and Strategic Command and Control (SCC) personnel under the Fully Automated Flight (FAF) hypothesis.
- By reducing the potential for flight crew errors under the hypothesis of FAF (at the cost however of losing the advantages of having pilots onboard to rectify other errors made by humans, i.e. design faults, faults through wear and tear, computer failures, ATS-faults, security faults etc).

Some problems posed by cockpit automation

Automation of course doesn’t presents only advantages. Different studies, especially in the Human Factors domain, have indeed indicated that automation modify the ways the pilots interact with the aircraft and between themselves. The main drawbacks that have been reported in the literature can be summarised as follows. For instance, feedback from check pilots instructing and assessing crew on current FMS-generation aircraft has generated the following list of reactions to automation (Chidester, 1999, summarised by M. Masson in Amalberti et al., 2000):

- Crew operating more automated aircraft describe a transfer of some aircraft control to PNF (Pilot Non Flying). With the introduction of flight management and guidance systems, the PNF now can (but should not) make changes in the flight path without prior PF's consent. If not counteracted by proper crew communication and co-ordination practices, this can transfer part of the situational lead to the PNF.

- There are comfort differences in the use of automation among pilots. The more comfortable with automation is a crew member, the more likely (s)he is to take the lead. In cases where it is the First Officer, the Captain can be occasionally left partly out of the loop.
- Among fleets operating this category of aircraft, there is at least the appearance of less standardisation because of the flexibility provided by automation. There are more ways to complete a given task and airline policies often allow for personal choice among acceptable techniques.
- Automation transfers workload among phases of flight. The workload is particularly high on the ground because of FMS programming, low in cruise and increases in approach in cases where ATC requests differ from the planned flight.
- Automation changes the timing of errors. FMS programming errors can remain latent for several hours, while a wrong course entered into the auto-pilot control unit has an immediate effect.
- Pilots may show a tendency to use the extremes of the automation range. Paradoxically, pilots attempt to program or reprogram the FMS when it creates additional workload or, on the other hand, to turn the automation completely off when some intermediate automation level would have made the task easier.
- Pilots may have difficulties in detecting (or understanding) automation failures. Pilots experience difficulties in assessing whether automation is failing or just behaving differently than expected.
- There may be a tendency to try to correct an “automation-induced” failure or event by manipulating automation rather than reverting to a lower automation level, including hand flying the aircraft.
- There are occasional instances of complacency or loss of situational awareness when flying in an automated mode.
- Pilots lose some basic flying skill when flying automated aircraft. In particular, ‘feel’ for the aircraft and planning skills may seem to deteriorate. This is a problem in case of automation failure and when transitioning back to traditional aircraft.
- Pilots experience situations in which the aircraft deviates from their intentions following selection of an autopilot mode. This may happen in two cases: a) inadvertent selection of a mode of data input by the pilot (input error, either mistake or finger error), or b). Selection of a mode whose performance actually differs from the expected one, possibly leading to a mode reversal. The latter is known as “automation surprises” or “mode errors” associated with failed ‘mode awareness’ (e.g. Sarter & Woods, 1995).
- Pilots may experience situations which for which the automation is not designed, and it may inadvertently exceed limitations forcing a sudden or gradual lead to automatic disconnect.

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The above list isn’t of course exhaustive, but it gives a good picture of the current situation. In addition, new automated control, command and assistance systems will surely *modify* the ways the different personnel will interact with the technology and between them, not only in the cockpit but also in the other nodes of the global AGS system. No doubt that the list of drawbacks and operational bottlenecks presented above, which characterise the present generation of aircraft operated within the present airspace paradigm, will evolve in the future. Some problems are likely to be resolved and other to be reinforced, while new problems due to the unique characteristics of the future global AGS system will probably arise. Among them are for instance the difficulty for each agent to be and remain aware of the state and dynamic behaviour of the other agents, human and artificial, within the global system, and the difficulty to operate in case of failure, breakdown or inoperability of the automated systems. Transition problems between different aircraft generations or between different airspace paradigms are also foreseen, as well as difficulties for pilots used to operate highly automated aircraft to revert to older generation aircraft.

In order to get the best possible results in terms of efficiency and safety from the future automation, “accompanying measures” such as adapted regulations, procedures, education and training, in particular Crew Resource Management (CRM) are necessary. How can for instance CRM improve safety in the context of advanced cockpit automation?

- By enhancing flight deck management and enabling safe and efficient responses by the flight crew that are unique to the command and control of an aircraft, in particular within a larger aviation system.
- By enhancing ATM/ATC resource management, and SCC resource management under the hypothesis of FAF, through adapted Team Resource Management (TRM).
- By enhancing maintenance resource and operation management, in particular while facing new aircraft, aircraft systems, communication and control technologies through adapted Maintenance Resource Management (MRM).

Implications for the other actors of the AGS system

As stressed before, the developments of cockpit automation will take place in the context of a new, global and integrated AGS system. The developments foreseen in the domain of cockpit automation will therefore also affect the *other* actors of the global AGS system, and introduce new requirements to a variety of actors in a variety of domains:

<u>Research community</u> (authorities, industry and academia)
Adapted funding and investments.
Adapted and timely research areas and topics.

<u>Regulators and certification authorities</u>

Need for a more transversal and global approach, with reinforced integration needs between different domains (e.g. flight crew, ATM/ATC, maintenance).
Need for further harmonization between different authorities (e.g. JAA, FAA) and regulations.

Education and training
Specialisation in each field, but with explicit references to the other domains in order to cope with the new airspace paradigm in which the various agents, both human and artificial, communicate and co-operate.
Explicit reference to the other agents is needed in particular during the transition phase between the current and the future air space paradigms, and should be considered as a standard requirement after the transition.
In addition, the objectives, contents and methods of all technical and non-technical education and training programmes need to be adapted. As mentioned before, this is in particular the case for CRM, TRM and MRM, which are powerful means to help the actors efficiently and safely interact with the technology, in the cockpit and in the rest of the global AGS system.

Flight crew and cabin crew
Need for adapted operational procedures (normal, abnormal, emergency), and crew practices and behaviours.
Need for adapted education and training, both technical and non-technical, including CRM.

ATM/ATC and SCC (under the Fully Automated Flight hypothesis)
Need for adapted operational procedures (normal, abnormal, emergency), and crew practices and behaviours.
Need for adapted education and training, both technical and non-technical, including TRM.
Need for intelligent routing systems, for instance self-separation systems (other traffic, weather).
Need for adapted interfaces between controlled traffic and controlled airspace**.**
Increased needs in terms of integration between different requests and constraints: requests by operators (pilots, operation offices), flow management and ATM constraints, contracts with the operators, and real time efficient and safe flight management.

Maintenance operations
Need for adapted maintenance procedures and practices, including of communication with other actors: flight crew, ground and operations personnel, and ATM/ATC and SCC personnel, especially but not only under the FAF hypothesis.
Need for adapted education and training, both technical and non-technical, including MRM.

Passenger and cargo operations
Need for passenger and cargo monitoring systems, and security systems, in particular under the FAF hypothesis.
Regarding the passenger operations, the FAF hypothesis might in addition lead to a redefinition of the roles of the cabin crew and security personnel, both on the ground and airborne.

Airport operations
Global need for reinforced security procedures, including against cyber-attacks and terrorism, in particular under the FAF hypothesis.

What does cockpit automation directly or indirectly affect in the system?

Advances in cockpit automation will not only affect aircraft but also the whole AGS system, which will also benefit from technical developments in the domains of automation, data-exchange (e.g. data-links) and assistance to operators (e.g. adaptive interfaces and other advanced AI systems, Computer Support to Cooperative Work – CSCW). This section presents a list of items concerned by cockpit automation developments. The list is not exhaustive. It simply contributes grasping the variety of aspects directly or indirectly concerned by the new automation developments.

Aircraft systems
Examples of systems concerned by the automation developments are listed below. They concern both normal and abnormal operations.

Onboard computers, sensors, wiring, software and hardware architectures.
Man-machine information and interaction systems, controls and commands.
Assistance systems, including AI-based systems.
Situation Awareness (SA) systems: horizontal and vertical representations and alerts, automation and mode awareness, traffic awareness, terrain and navigation awareness systems.
Data base issues: information and control interfaces, paging and navigational issues.
Communication systems, using different channels and types: acoustic-auditory (verbal and non verbal), optical-visual, tactile information and control.
Aircraft performance, navigational & operational data and systems: air mass based and earth reference trajectories computation, vertical and lateral (envelope-future), time, altitude constraints, wind, RNP & Vertical RNP, operating environment (altitude regime), automatic selection of radio navigation aids, clearance & weather/wind data, engine out, altitude & speed information.
Fuel monitoring including dumping fuel, engine monitoring, aircraft systems monitoring.
Wind shear protection.
Guidance generation, holding pattern & procedures monitoring, possible interface with automated flight bag.
Airport diversions, alternate flight plan, airline or operator preferences, optimisation (cost index, fuel consumption), operational and time constraints (flight connections, Hub integration, ATC slots, facility/base operation and maintenance), noise, safety, security issues.
Etc.

CNS/ATM/ATC systems and data (for normal and abnormal operations)
Systems supporting safe, efficient route and schedule planning for aircraft/spacecraft, including safe separation between all aircraft in the airspace, meteorological considerations, deteriorated aircraft performance and environmental considerations.

Real-Time management of aircraft routes (gate-to-gate), separations, obstacle/terrain clearances and schedules, including safe separation between all aircraft in the airspace, meteorological considerations, deteriorated aircraft performance, environmental considerations, alerting and assisting necessary authorities for aircraft in need of search & rescue
Emergency separation assurance services in the air and on the ground (ASAS/CDTI, e.g. TCAS, ASMGCS).
Integration to, or interaction with, SCC (Supervisory Control and Command) under the FAF Hypothesis.
Etc.

AGS data-links and communication systems (for normal and abnormal operations)
Air / Air: communication links with other traffic.
Ground / Air: communication links between traffic, ATM/ATC and SCC under the FAF hypothesis.
Space / Ground / Air communication links.

Design and operation of the global AGS system
The development of cockpit automation must be considered in relation to the design and operation of the global AGC system in which aircraft will be operated.

Regulations, standards and procedures
Regulations and standards, as well as philosophies, policies, procedures and practices need to be adapted to the developments of cockpit automation and the new air space paradigm, and in relation to culture.

Culture
Culture can be defined as the values, beliefs, attitudes and behaviours that members of a group share. Different groups or group levels can be considered, which defines different sorts or levels of culture, such as the national culture, regional culture, professional culture, airline culture, ATM/ATC culture, etc.
All types and levels will be affected by the foreseen developments in terms of cockpit and the globalisation of the AGS system: from the global aeronautical culture to corporate culture, pilots culture, controllers culture, maintenance culture, etc.
The concept of safety culture will also be affected, and its importance for safety emphasised.

Certification
Developments in terms of cockpit automation and the emergence of a new, global and integrated AGS system will pose new demands in terms of certification. Regulation and certification authorities will therefore be concerned.

Education and Training
Those developments will also introduce new requirements in terms of education and training (simulator, but also class room and on-the-job training) of pilots, and of other categories of personnel such as ATM/ATC, maintenance, security and ground personnel, and SCC in the hypothesis of FAF.

Selection, recruitment and evaluation
The way pilots and other qualified personnel will be selected, recruited and evaluated will also be affected.

Accident investigation
Investigators will need to be educated about the developments of cockpit automation and the characteristics of the new AGS system.
Courts and legal system should also be informed, as the characteristics of this new system might affect the attribution of responsibility and other liability issues in case of accident.

Quality and safety management
Quality and safety management, flight data analysis, incident reporting and analysis at the airline level.
Quality and safety management, performance analysis, incident reporting and analysis regarding the ATM/ATC operations, and SCC operations in the hypothesis of FAF, and at the global AGS system.

Security and security management
All components of the AGS system are concerned, e.g. the airlines, airports, ATC/ATM and SCC in the hypothesis of FAF, maintenance organisations, cargo integrators, etc.
Developments are expected in the domain cyber-security due to the increasing importance of software, databases and data communication issues.

Who in the system are concerned?

As it appears from the above list, cockpit automation directly or remotely affects a larger number of personnel than just the pilots. And not only does it affect individual agents but also the global AGS system. This section looks into the various actors of that global system impacted by cockpit automation. All the actors listed below have a physical or functional interface with the cockpit. Practically all actors are concerned, at various degrees, and at the various design, production, certification, operation and maintenance phases of the production cycle.

Authorities
Civil aviation authorities including ATM /ATC authorities (e.g. certification issues).
Military aviation authorities and defence services (e.g. security issues).
Courts and legal system (e.g. responsibility and liability issues in case of accident).
Political authorities, national and international.

Manufacturers
Manufacturers and equipment suppliers of hardware and software (e.g. data bases), including designers and vendors.

The various personnel onboard the aircraft
Flight crews: flight deck crew and rest crew in case of long haul flights (e.g. hand-off and situation awareness issues).
Cabin Crew.

Security personnel.
Medical personnel.
Passengers.

Air Traffic and Operation Control and Management
Other traffic.
ATM/ATC personnel: radar/executive controller, data/planning controller, flow managers (within regional and wider area centres), tower and approach controllers, ground/ramp controllers, aeronautical information services/flight safety services, etc.
Weather services.
And under the FAF hypothesis: Integrated Airline Operational Command, Air Traffic Management & aircraft control functions within a ground based SCC system, and supervisory personnel (safety & security monitoring on ground or airborne).

Airlines and alliances
Operations.
AOC, Dispatch, load control/masters.
Quality and safety management, personnel in charge of FOQA/FDMP (flight data monitoring programs).
Training.
Security.
Maintenance and engineering (line maintenance and industrial maintenance).
Cargo integrators and cargo operations.
Human resources management.
Airline and alliances management.
Market and finance management.

Maintenance organisations
Production.
Engineering.
Training.
Quality and safety management.
Management.

Ground operations
Airport operations (fire, security and airport maintenance) and emergency services (SAR).
Ground personnel.
Security personnel.
Management.

Customers, professional and political actors
Non-flying public (public opinion).
Unions and professional organisations.
Insurance companies.
Other financial and market actors (e.g. banks).

Training and research actors (authorities, industry, academia)
Training and licensing personnel.
Research community.

Where in the system will cockpit automation have impacts?

This section reviews the main physical locations, organisational functions or activities within the global Air, Ground & Space system directly or indirectly concerned by cockpit automation. Virtually all locations, functions or activities in the system are concerned, at various degrees.

Aircraft
Cockpit / flight deck (functionally both a crew command post and a maintenance terminal).
Cabin (especially under the FAF hypothesis).
Crew rest areas (flight crew and cabin crew).

ATM/ATC and SCC facilities (under the FAF hypothesis)
SCC possibly featuring integrated Airline Operational Command, Air Traffic Management & Aircraft Control functions.

Airlines
Airline operations (flight planning office, crew check-in, etc.)
Airline maintenance.
Airline quality and safety management, flight data analysis, incident reporting and analysis.

Ground activities
The various ground and ramp facilities, organisations and activities.

Accident investigation
Accident investigation activities (investigators will need to be educated about the developments of cockpit automation and the characteristics of the new AGS system).

Education and training facilities (authorities, industry, academia)
Flight crew and cabin crew, including security and medical personnel (especially under the FAF hypothesis) training facilities.
ATM/ATC and SCC (under the FAF hypothesis) training facilities.
Maintenance training facilities, including on-the-job training (OJT).
Ground personnel training facilities.

Manufacturers & equipment providers
Manufacturers, equipment suppliers and vendors of hardware, and software (e.g. data bases) applications (e.g. concepts / project teams, aircraft architecture integration, ground / air / space integration).

Space-based elements
Satellites and data transmission / communication links.

When in the system life cycle will cockpit automation have impacts?

This section quickly reviews the various phases of the global AGS live cycle impacted by cockpit automation. Practically all design, production, certification, operation and maintenance phases of a classical production cycle are concerned. The main ones are listed here below. Beside normal operations, special concerns are raised in case of abnormal, failure, emergency, crisis management and evacuation conditions due to the characteristics of the new AGS system.

Research
Research areas need to be properly and timely selected and supported.

Design and manufacturing
In particular operational concept studies in design.

Certification
Including continuous airworthiness.

Education and training
All personnel and actors concerned need to be properly and timely educated and trained to use advanced automation and play their role within the new AGS system.

All phases of operations
Entry into service, operations, maintenance, modifications and retrofits, replacement, etc.

Airline operations
Dispatch
Flight planning office, crew check-in, etc.
Load control, in the FAF hypothesis, in particular for cargo operations.
Airline quality and safety management, flight data analysis (FOCA-like programs), incident reporting and analysis.

Maintenance
All maintenance operations.
Special impact on line-maintenance for pre-flight and post-flight operations, including troubleshooting, in particular under the FAF hypothesis due to the absence of flight-crew (lack of direct communication, increased reliance on on-board maintenance data systems).

Ground operations
All other ground operations.
Special emphasis in the hypothesis of FAF due to the absence of flight crew onboard (lack of human redundancy for the safety and security of ground operations).

Security operations
All security operations, including against cyber-attacks due to the inter-dependency of all nodes in the global AGS system and the increased role of data bases and data exchanges (e.g. data links).

Flight operations
All flight operations in all phases of flight are concerned, in particular those phases close to terrain, including flight preparation.

Flow management operations, ATM/ATC operations, and SCC operations (under the FAF hypothesis)
All ATM/ATC operations and SCC operations under the FAFA hypothesis are concerned.

Accident investigation and court proceedings
Accident investigators, lawyers, professional and passenger organisations need to be informed of the developments of cockpit automation and the characteristics of the new, global AGS system as they may affect responsibility and liability matters.

Quality and safety management
Quality and safety management, flight data analysis (FOCA-like programs), incident reporting and analysis, concerning all categories of operations and personnel: flight crew, cabin crew, maintenance and airline operations (see above), ATM/ATC operations, security personnel and SCC personnel (under the Fully Automated Flight hypothesis).