



Integration of Remotely Piloted Aircraft Systems in European Airspace

A study of the Human Factors impact on Air Traffic Controllers

Customer

National Aerospace Laboratory NLR

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EXECUTIVE SUMMARY

Integration of Remotely Piloted Aircraft Systems in European Airspace

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Problem area

The technology of Remotely Piloted Aircraft Systems (RPAS) is becoming ever more available, and the demand for their application for civilian operations within civil airspace is increasing. The European Commission is intending to enable the seamless operation of RPAS within controlled airspace alongside other users. This paper investigates the human factors impact of RPAS operations within controlled airspace on the Air Traffic Controllers (ATCOs).

Description of work

This paper reports the findings of an internal study. Two workshops were carried out to identify human factors issues of ATCO using operational scenarios focused on Medium Altitude Long Endurance RPAS operations. The workshops were carried out with both military and civil ATC personnel.

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Operator Performance
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Task Analysis

Results and conclusions

The results of the human factors analysis of the scenarios that were assessed in the workshops indicate that there is a potential impact on the human factors of ATCOs. The cognitive processes were considered in three categories: Situation Assessment, Attention & workload management, Problem solving & decision making.

This study has identified several factors that may affect the performance of the ATCOs when integrating operations of RPAS within civil airspace. During the initial phases of integration there is expected to be a larger impact on the ATCOs, which may impact the performance of the ATCOs, and consequently the airspace capacity.

Applicability

The findings of this study are applicable to provide background and advice to air navigation service providers. It is important to them to understand the impact and implications of RPAS integration early in order to prepare their controllers properly. The results of the study can inform the development of recommendations and regulations within the ATC community.



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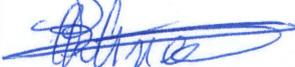
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Summary

The technology of Remotely Piloted Aircraft Systems (RPAS) is becoming ever more available, and the demand for their application within civil airspace is increasing.

Current operations in European airspace are almost exclusively military or research operations, and limited to segregated blocks of airspace. The European Commission is intending to enable the seamless operation of RPAS within controlled airspace alongside other users. This study investigates the human factors impact of RPAS operations within controlled airspace on the Air Traffic Controllers (ATCOs). The results of a human factors analysis of scenarios that were assessed in workshops indicate that there is a potential impact on the ATCOs. This report provides input for the discussion concerning the integration of RPAS from the ATCO's perspective.

Keywords: Human Factors, Task Analysis, Air Traffic Management, RPAS, UAV

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Abbreviations

Acronym	Description
ACoPOS	ATC Cognitive Process & Operational Situation
ANSP	Air Navigation Service Provider
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATM	Air Traffic Management
EASA	European Aviation Safety Agency
EC	European Commission
EU	European Union
HF	Human Factors
IFR	Instrument Flight Rules
LVNL	Air Traffic Control the Netherlands
MALE	Medium Altitude Long Endurance
NATO	North Atlantic Treaty Organisation
NPA	Notice of Proposed Amendment
RPAS	Remotely Piloted Aircraft Systems
UAV	Unmanned Air Vehicle
VFR	Visual Flight Rules

1 Introduction

Medium Altitude Long Endurance (MALE) Remotely Piloted Aircraft Systems (RPAS) are currently almost exclusively deployed for military operations. Outside Europe MALE RPAS are already applied for other government peacetime operations, such as for border patrol, coastal surveillance and police support. These applications are being examined within Europe, and are likely to be introduced in the near future. In addition, civilian commercial applications for MALE vehicles, such as cargo, photography and remote sensing operations, are also real possibilities in the future. Eurocontrol foresees that 6% of air movements will be unmanned by 2020. It is therefore not surprising that the integration of RPAS in controlled airspace is an important aim of the European Commission. Controlled airspace includes all classes of airspace in which Air Traffic Control (ATC) services are provided. Currently, RPAS operations are usually confined to military airspace, or segregated blocks within civilian ATC controlled airspace. The intention of the European Commission (EC) however, is to enable the seamless operation of RPAS within controlled airspace alongside other airspace users, without the requirement for additional segregation (EC, 2013).

In the last couple of years several research initiatives have been set up that primarily focus on the technical, procedural and regulative aspects related to the integration of RPAS. Relatively little attention has been given to the Human Factors (HF) impact on Air Traffic Controllers (ATCOs), which is the main issue of this paper. Since missions and procedures of RPAS will typically differ from manned aircraft – either in their content, or duration – a consideration of the effects on ATCOs' situation awareness, workload management and decision making should be included. An analysis of the HF implications for ATCOs is essential to ensure a safe and efficient introduction of RPAS in controlled airspace. This analysis can contribute to the formulation of adequate regulations regarding the integration of RPAS, and advise Air traffic Navigation Service Providers (ANSPs) regarding system development and training requirements.

There has recently been an explosion of interest and activity in small RPAS operations within Europe. However, these RPAS, which typically have an operational mass below 150 kg and would usually operate within Visual Flight Rules (VFR) airspace, are a different type of operation to the larger RPAS considered in this paper. We have concentrated on studying the impact of RPAS operations within controlled airspace, and within an Instrument Flight Rules (IFR) operational concept – focusing on the effect on the ATCOs responsible for the airspace.

This paper is based on a study to carry out a HF analysis of the effects of integrating RPAS operations into controlled airspace on ATCOs and their task. The main research question was whether ATCOs are affected by possible future RPAS operations in controlled airspace in terms of workload, situation awareness and decision making. The results of this analysis are intended to identify potential mitigations to provide information to the regulators and service providers. Meanwhile this paper is also intended to increase the awareness and understanding of the impact of RPAS operations within the ATC community, and thereby inform the discussion within ANSPs, the RPAS community and regulators.

2 Background

The legislative requirements under which RPAS currently operate, the rules and regulations within Europe and the Member States are still in development. As such, there is a clear benefit for this process in gaining more insights into the effects of RPAS integration on the ATC operators involved.

2.1 Rules and guidelines within Europe

RPAS are regulated under the Chicago Convention on International Civil Aviation Organisation (ICAO). ICAO has established this under ICAO Circular 328 on Unmanned Aircraft Systems (UAS), published in 2011. This is being applied within Europe as proposed under European Aviation Safety Agency (EASA) Notice of Proposed Amendment (NPA) 2012-10. According to Article 4.4 of EC regulation 216/2008, the responsibility for the certification and operational approval for RPAS used for civil applications of 150 kg or more maximum take-off mass lies with EASA. However, RPAS used for military and non-military governmental operations, experimental flights, civil RPAS below 150 kg, as well as model aircraft are regulated by individual Member States and thereby remain the responsibility of individual national aviation authorities. This can be interpreted that currently, RPAS with an operating mass greater than 150 kg that are used for non-military governmental operations (such as coastguard, police or border patrol) or military operations are still regulated by the national aviation authorities.

Due to the fast growing nature of this area of aviation, the regulatory materials are still in development. EASA has included RPAS regulations in the current rulemaking programme, and is working within several rulemaking groups to support the development of certification and operation requirements and guidance. This includes the Joint Authorities for Rulemaking on Unmanned Systems (JARUS) and the ICAO UAS Study Group. The rulemaking activities for RPAS are intended to establish requirements for:

- Licensing of remote pilots;
- RPAS operators, and RPAS training organisations;
- Certification specification for vehicles not covered by existing regulations;
- Safety objectives and processes for airworthiness;
- Systems – communications and datalink, detect-and-avoid systems.

2.2 Airspace integration

RPAS operations are currently limited to segregated airspace blocks in the Netherlands, and internationally. Integration with other airspace users within controlled airspace only occurs on a

sporadic basis, typically in support of experimental or military operations. Guidelines for the integration of RPAS within the civil airspace system are being published by the regulatory authorities (e.g. ICAO, FAA, EASA, Eurocontrol). The focus of these activities is currently technology based on the detect-and-avoid capability of the RPAS. There are a number of requirements on the RPAS pilot based on existing studies to determine the skills required for RPAS operation.

From the perspective of the ATC system, the aim of the integration development is to ensure that RPAS are transparent to the ATC system, and can be integrated in the same way as any other air vehicle. Hence, a basic principle of research into RPAS integration within civilian airspace is that there should be no impact on the ATM system as it currently stands, and this has been the case since the early research projects (e.g. USICO, 2004). The European roadmap describes it as such: *“RPAS have to comply with the aviation rules. In other words, RPAS integration should not impact on the current airspace users (i.e. no degradation of the safety in the air; no disruption of current operations; no modification of ATC procedures; no additional mandatory equipment caused by RPAS).”* (p6, EC, 2013).

This underlying integration principle implies that there will be little requirement for change within the ATM system, or for the ATCOs. However, the regulatory and research roadmap of the regulatory authorities therefore also highlights the need to include the HF of the ATCO (e.g. FAA, 2013; EC, 2013).

2.3 Integration phases

The research into integration that was described in interviews with operational personnel was described in terms of four phases:

1. Segregated airspace. RPAS operations are carried out using dedicated airspace areas.
2. Sense & Avoid operations. Where an RPAS pilot is able to carry out radar separation, an RPAS may be permitted to operate in partially segregated airspace.
3. Transponder. An RPA fitted with a transponder and sense & avoid capability is permitted to operate in Class D airspace, where transponders are required for radar separation.
4. See & Avoid. Fully integrated operations, which are carried out through a combination of radar, sensor and visual separation with other traffic. The RPA can operate in all airspace (Class A-D), which would also include non-segregated operations with VFR traffic.

In general through the implication of these integration phases, the RPAS is intended to present the same operational factors and problems as other air traffic. The activities described by the European roadmap also broadly follow these phases (EC, 2013). This paper assumes the fourth of these phases in the operational situations analysed for the HF impact. In this case the RPAS operates within controlled airspace alongside other airspace users, following IFR or VFR.

2.4 Related research activities

A number of European Union (EU) wide research projects are or have been recently undertaken to investigate the integration of RPAS into civil controlled airspace and help to establish rules and regulations (e.g. Eurocontrol research projects, NATO working groups, and EC projects such as SINUE, USICO, and most recently CLAIRE and AIRICA). These projects investigate multiple aspects that are associated with the integration of RPAS, which include factors that have a bearing on the HF for the ATCO. Three of the key projects from this perspective are the Eurocontrol research project to establish guidelines for the Global Hawk RPAS (Eurocontrol, 2010) the EU Roadmap on RPAS Air Traffic Management (ATM) integration (EC, 2013), and the NATO-FINAS working group.

In sum, it stands out that although these projects have been conducted by multidisciplinary work groups it is unclear to what extent HF aspects of the ATCO have been taken into account. Moreover, mostly the RPAS pilot perspective prevails. There seems to be a clear need to apply the same procedures and requirements for unmanned aircraft as for manned aircraft. While this seems plausible on the first instance, the question remains whether this is (a) possible and (b) necessary. RPAS fly different missions and are characterized by different performance parameters, which provide possibilities to accept different requirements. The present study therefore is important because it expands current research activities and insights by investigating the requirements for RPAS operations that are indispensable from the perspective of the ATCO. It therefore provides input material for the discussion and development of regulations that enable the integration of RPAS into controlled airspace.

3 Method

Two workshops were held with ATC personnel – one with military personnel, and one with civilian personnel. The participants consisted of ATCOs (2 military ATCOs, 6 civilian ATCOs), and also included a supervisor, a HF expert, and an operations manager. The military workshop took place in a single session. The civilian workshop was split into two sessions with 3 ATCOs from Maastricht Upper Area Control in each session. The participants were male and had more than 10 years of work experience and represented different sectors.

3.1 Scenarios

A scenario-based approach was applied to identify HF impacts on ATCOs' performance. The scenarios aimed to place the participants in a future situation in which a MALE RPAS flies through their sector in order to elicit ATCOs reactions on potential issues resulting from the integration of unmanned aircraft. The scenarios covered different operational RPAS situations, namely one normal operation, an emergency operation, and one out-of-the-box operation in which ATC can directly control the RPAS. A contemporary scenario with a manned aircraft flying the same operation as the RPAS was included to familiarize controllers with the scenario-based method and to provide a baseline measurement. The description of each scenario was rather high level with the aim that controllers would not be biased by technology, procedure or regulations. In addition, the scenarios deliberately focused on governmental rather than military operations as this goes a step further into the future than currently foreseen RPAS integration in the short-term. The scenarios are described below.

3.1.1 Scenario 1 – A manned border patrol flight

"You are working a day shift as executive controller. It is around 10 o'clock in the morning and there is a lot of transit traffic. The Mil-ATC call in. A patrol aircraft is on its way and needs to climb through your sector. It will then assume a patrol area above the Dutch-German border. The racetrack pattern is set at FL320 on the edge of your sector. The flight is operated together with NATO by an AWACS aircraft."

3.1.2 Scenario 2 – An unmanned border patrol flight

"You are working a day shift as executive controller. It is around 10 o'clock in the morning and there is a lot of transit traffic. The Dutch Border Police call to inform you that a patrol aircraft is on its way to patrol the Dutch-German border area in your sector. It will be operating a racetrack hold at FL320. Since the usual patrol aircraft is in maintenance, the flight will be operated by a

Coastguard Guardian RPAS today. You communicate directly with the RPAS pilot – a police officer trained in RPAS operations – on the radio frequency.”

3.1.3 Scenario 3 – Guardian RPAS with lost link

“You are still on your day shift. The Guardian RPAS is flying its mission in your sector. The transponder code changes to 7600 and the pilot confirms via landline that any link with the RPAS has been lost. On your radar display you see that the RPAS is climbing to FL420 as per the lost link procedure. Once at altitude, it flies to a hold pattern over EHVK. Its detect-and-avoid systems ensure separation during the climb and hold”.

3.1.4 Scenario 4 – Further in the future: ATCO has partial control

“You are working your day shift on one of the FABEC sectors. At the start of your shift you see that a coast guard patrol flight is planned in your sector. Once it enters your sector, it assumes its pre-planned mission track at FL320. It flies autonomously and uses detect-and-avoid to ensure separation. Changes in the altitude, speed and route are sent directly to the RPAS from your working position.”

3.2 ACoPOS model

Figure 1 shows the ATC Cognitive Process & Operational Situation (ACoPOS) model (Schuver-van Blanken, Huisman, & Roerdink, 2010), which provided the theoretical framework for carrying out the HF analysis on the various scenarios. The ACoPOS model describes the ATC tasks in terms of the operational situation and in terms of cognitive processes of ATCOs. In the present study it was assumed that the integration of RPAS in controlled airspace will change the operational situation, and it was studied whether this affects controllers’ cognitive processing.

The cognitive processes described in the ACoPOS Model include: situation assessment; attention management; workload management; problem solving & decision making; and actions. Situation assessment is a continuous process, which results in situation awareness, i.e. the mental picture of the situation. Situation awareness requires that information be constantly perceived and interpreted to build a mental picture of the current situation, as well as to be able to anticipate future situations. Attention & workload management refers to the ability to divide attention among different task, and to keep workload at an acceptable level. For example, an ATCO can work concentrated in situations with little traffic, and adjust the way of working when traffic increases in order to keep workload at an acceptable level. Problem solving & decision making is required in solving conflicts and making a (conflict-free) planning. These cognitive processes include setting priorities, show initiative, and act early and decisive. Actions include the various

activities of ATCOs, such as communicating (via radio, telephone and live), inputs to systems, strip- and label management, and all actions facilitating teamwork.

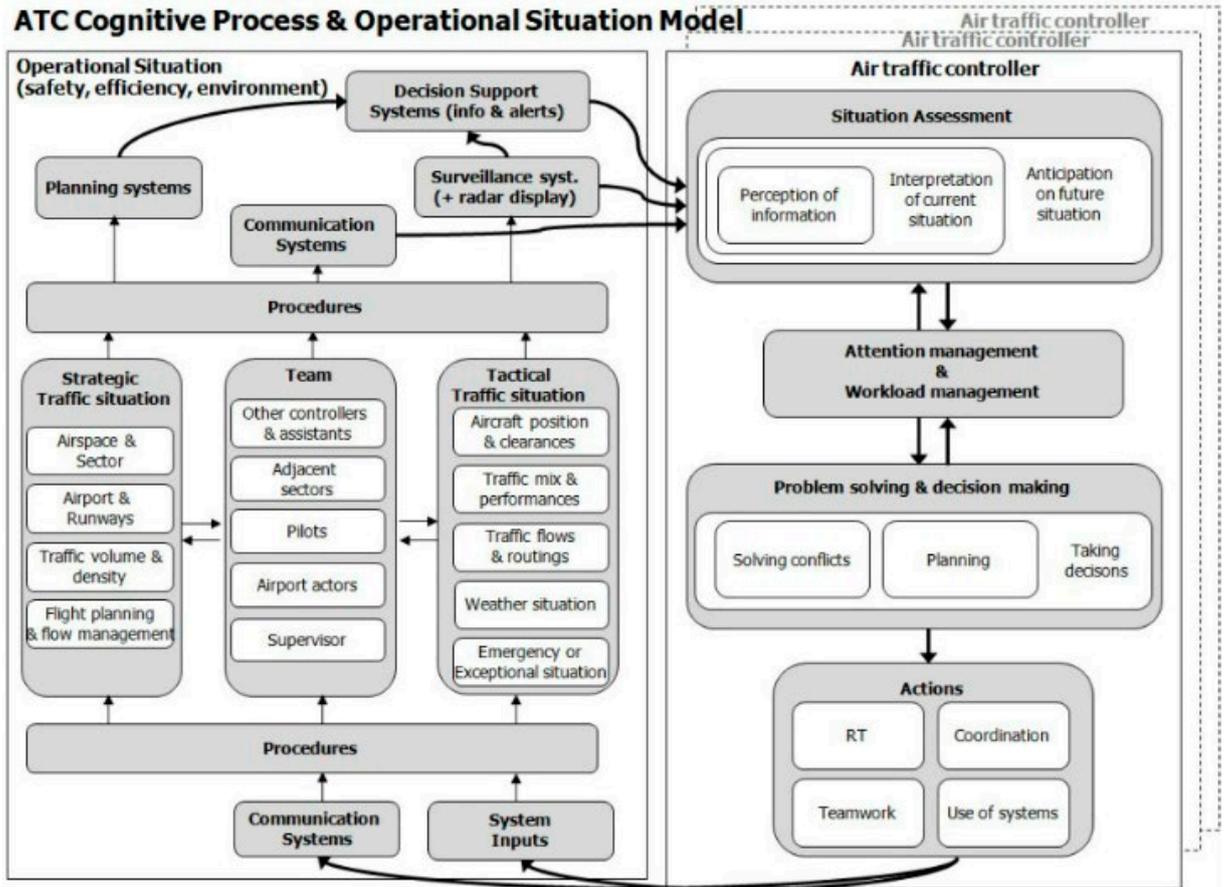


Figure 1 Representation of the ACoPOS model (Schuver-van Blanken, Huisman, & Roerdink, 2010)

3.3 HF rating scale

ATCOs filled in a rating scale that assessed the five HF aspects of the ACoPOS model (i.e. situation assessment, workload & attention management, problem solving & decision making, and actions & teamwork). For each scenario ATCOs rated on a 5-point scale how heavily the scenario affects a specific HF aspect in terms of change of the HF aspect ('no impact' to 'very high impact'), and in terms of complexity of the HF aspect ('less complex' to 'more complex') compared to current day operations. For example, a future scenario could heavily affect decision making (effect on change) in a positive way, making it easier to make decisions (effect on complexity). This analysis is based on a methodology developed at the Dutch Air Traffic Control (LVNL) to classify a new concept of operation in the ATM system (e.g. new systems, procedures or staffing) in terms of its impact on the change of HF aspects and on the complexity of this change (Roerdink, Schuver-van Blanken & Huisman, 2010). The LVNL methodology includes also a weighting of importance of the

different HF aspects, which was not included in the present study. In this study all aspects were evaluated to the same degree. Furthermore, the method was developed as a tool for HF experts rather than ATCOs. The method provided quantitative data in addition to the more qualitative information that came from the workshop, and allowed for an assessment of the individual opinions of the ATCOs. The weight rating was not included as it is rather abstract (and therefore difficult to reliably rate by ATCOs), and because it was not an objective of the project. ATCOs evaluated the impact from an executive controller perspective, but could indicate on the rating form when they expected different impact on the planner controller.

3.4 Semi-structured debriefing

Per scenario a plenary semi-structured debriefing was conducted which focused on three main questions, namely (1) What is the impact on your performance? (2) What problems do you foresee? (3) What additional needs do you have to accommodate this? ATCOs were asked to discuss these questions with the HF aspects in mind that they had rated beforehand. In addition, the discussion leader structured the discussion according to these HF aspects.

3.5 Procedure

At the beginning of both workshop sessions, the HF aspects of the ACoPOS model were introduced to the ATCOs. The aim was to create a common understanding of the HF aspects. The participants were then presented with the scenarios (one at a time) on a power-point slide and were given the time they needed to read the scenario. After that the participants filled in the HF rating scale individually. Letting ATCOs fill in the rating scale first aimed to stimulate their thinking process regarding the relevant HF aspects and to avoid the influence of group dynamics in evaluating the scenarios. Next, the discussion leader initiated the semi-structured debriefing. ATCO comments during the plenary debriefing were recorded and one researcher made notes as well. The comments were classified according to the HF constructs of the ACoPOS model later on by the researchers involved in the workshop.

4 Results

4.1 Controller feedback

The implications of the RPAS integration scenarios on the cognitive processes as described in the ACoPOS Model (Situation assessment, attention and workload management, problem solving & decision making, and actions & teamwork) were considered per scenario. This qualitative assessment was used to define the overview of factors that affect the performance of the controllers, and consequently the capacity of operations, when RPAS are included in controlled airspace.

The missions that were considered in the scenarios had the primary impact on the situation assessment for the ATCOs. Due to the predictable nature of the flightpath, there was not expected to be a major impact on the situation assessment. The least predictable scenario – the lost link – was resolved by the expectation that the pre-defined procedure would be well defined and known to ATC. The attention and workload management, however, was expected to be affected by the fact that the flight was operated by an RPAS. Initially at least, it was felt that additional attention would be required to handle RPAS flights. The more that the experience of the pilots, and the method of handling, is similar to other commercial traffic, the lower the impact was expected to be. Similarly, the workshop participants indicated that the more ATCOs are exposed to RPAS operations, the more that their experience will enable them to treat RPAS the same as any other flight.

In the event of deviations from the expected flight path, the decisions and problem solving aspects of the ATCO's task related to RPAS operations was expected to be affected by the ATCO's experience of these operations. There may be a tendency to adjust and divert other traffic to compensate for the RPAS if this is seen as a simpler and more effective intervention. Also if the ability of the RPAS pilot differs to that of other pilots, this will need to be taken into account when handling the RPAS and any associated decisions. An aspect that could play a role is the ability of the RPAS pilots to visually separate themselves from other aircraft, or lack thereof. These factors must be taken into account by the ATCOs handling the RPAS flight. From the perspective of teamwork, a number of aspects related to the "airspace team" – pilots, controllers – were discussed centring on the need for the RPAS pilot to be an equal team member.

The outcome of the analysis of the cognitive process was to establish factors of RPAS operations that impact the ATCO task, and consider how these could be mitigated – from the perspective of

the ATCOs. These are outlined in Table 1 below. While some of these factors are not exclusively associated to RPAS, they do play a role in their introduction in controlled airspace.

Table 1 HF implications for ATCOs

Novelty	The novelty of the flight has an impact on the controllers. If controllers have little or no experience with a particular type of aircraft or flight profile (e.g. a race track patrol), the controller will need to pay more attention to it.
Predictability	Controllers are able to adapt to the RPAS operations as they become more familiar with their flights and types of operation. As the level of familiarisation in dealing with pilots increases, the trust between the pilot and the controller will build, which reduces the impact of RPAS operations on the controllers (compared to operations with other aircraft). The more predictable the nature of the mission flown by the RPAS, the lower the impact will be on the ATCO.
RPAS phase of flight	During the transitional phases of flight (climb or descent) the behaviour of the RPAS is expected to be less predictable than during the operational mission phase. In these phases the RPAS will require more attention from the ATCO than while the aircraft is in cruise or on its patrol race-track.
Operational flight level	Related to the types of missions that are likely to be carried out by RPAS, the operational flight level of the RPAS can have an impact on the workload for the ATCO. Certain flight levels are more intensively used by commercial air traffic than others. An operation that would use, or transition between, several flight levels would also have a more serious impact, compared to conventional traffic that transitions through sectors at set flight levels or flight profiles. In some cases the flight level required by the RPAS may necessitate that the flight level or airspace needs to be closed to other traffic.
Planned versus unplanned	A planned flight plan and operation using an RPAS enables the sector capacity to be adjusted to take the RPAS into account. In the event of an unplanned RPAS operation, such as in support of a search and rescue operation, the existing plan for the airspace sector needs to be revised, which will be less efficient.
Airspace type	The type of controlled airspace that is being used by the RPAS has an effect on the level of impact for the ATCO. In smaller and busier sectors it will be more difficult to accommodate RPAS operations, particularly in the event of the reconnaissance/patrol type operations considered.

Sector borders	It has been proven in normal operations that more incidents occur in the vicinity of sector borders, due to hand-over issues. If an RPAS is being deployed for national border patrol missions, it is likely to be flying in the vicinity of sector borders, thus further increasing the workload for the ATCOs involved.
Lost link procedures	Lost link procedures need to be well known to ATCOs – either relatively standardised for particular aircraft/operations, or published in advance. Lost link procedures are likely to include altitude changes that may be unannounced (through communications). This may be a more significant deviation from the original flight plan than would be expected for a commercial flight that loses communication. The impact of a lost link procedure for an RPAS on the ATCO may therefore be more pronounced than a commercial aircraft.

These factors have been identified in relation to the RPAS operations that were considered in this study. In the short to medium term the RPAS operations that are likely for MALE RPAS are believed to be related to reconnaissance and patrol activities – either for civilian government agencies (e.g. search and rescue, police, customs) or commercial activities (e.g. photography, surveys).

4.2 Controller ratings

Figure 2 shows the results of the controllers' rating of the impact on HF constructs (situation assessment, attention and workload management, problem solving & decision making, actions & teamwork). The magnitude of the impact was rated on a scale 1 (no impact) to 5 (very high) and the impact on complexity (Figure 3) was rated on a scale of -2 (less complex) to 2 (more complex) for the different constructs.

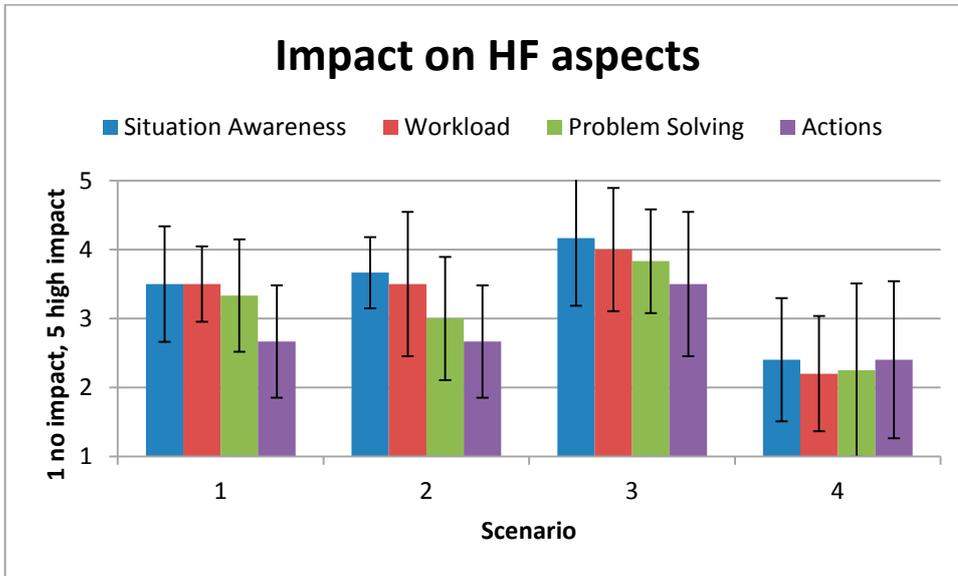


Figure 2 Controller ratings on the impact of RPAS operations on HF constructs for each scenario (error bars represent 1 standard deviation above and one below)

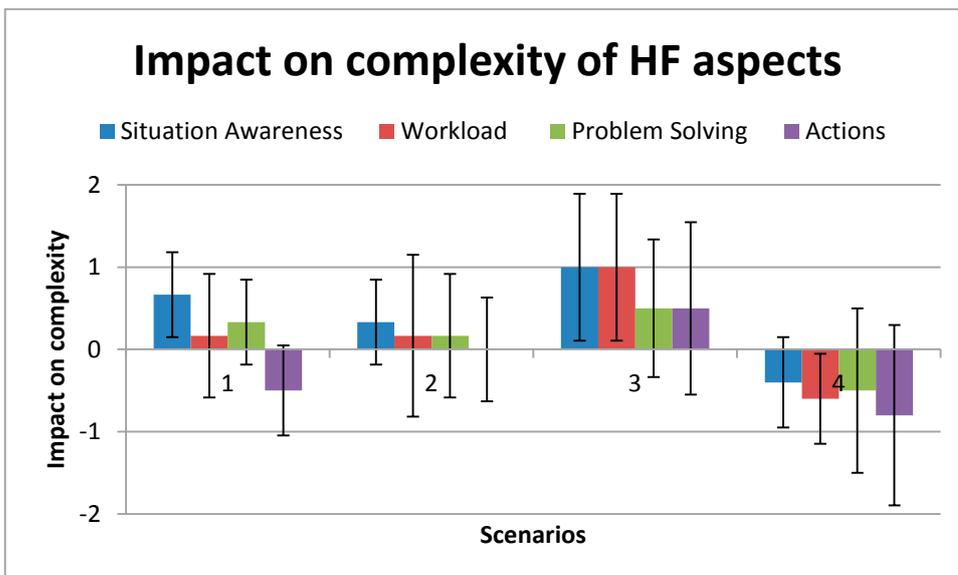


Figure 3 Controller ratings on the impact of RPAS operations on the complexity of change of HF constructs for each scenario (error bars represent 1 standard deviation above and one below)

Figure 2 and 3 show that the variation in the answers given by the controllers is quite high, but a trend might be recognised that the impact of scenario 3 is the highest. Furthermore, situational awareness and workload management seem to be impacted more than problem solving and decision making or performing actions.

Figure 4 shows the average impact on the HF constructs on the horizontal axis (all constructs were included to the same degree) and the impact on complexity on the vertical axis. Looking at the impact of the scenarios on the different constructs, the trend for each of the HF constructs is identical for both magnitude of impact and the impact on complexity. For scenario 1 the impact is rated 3.17 (3 is the rating in the middle, representing a medium impact), for scenario 2 this is similar (average 3.17), the impact of scenario 3 is rated higher (average 3.8) and the impact of scenario 4 is rated lower than all other scenarios (2.25).

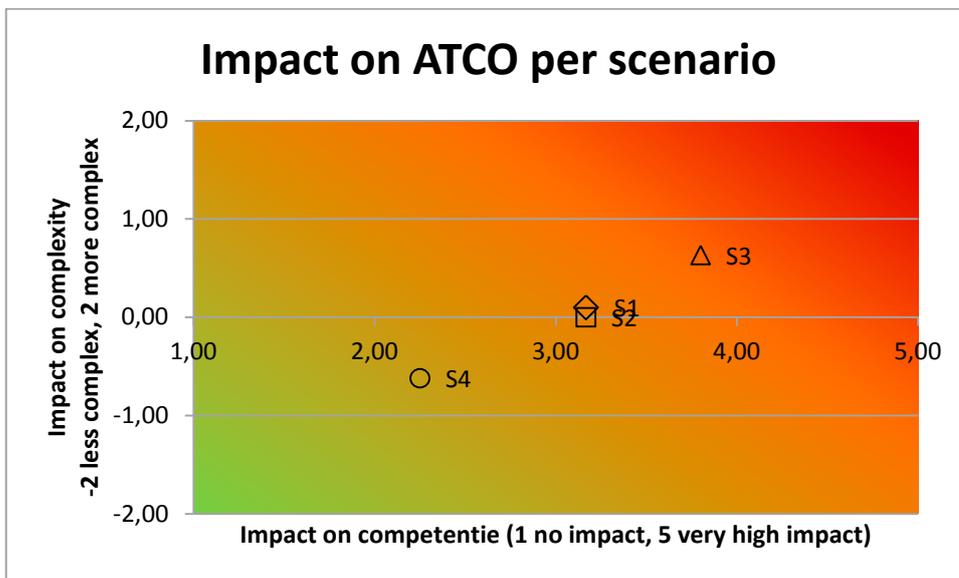


Figure 4 Average impact ratings and complexity for each of the scenarios (S0 to S3)

The magnitude of the impact and the impact on the complexity seem to correlate. This trend is identical for both the average overall outcome as well as for each of the constructs.

5 Discussion

The aim of this study was to investigate the HF implications on ATCOs of RPAS operations in controlled airspace. The focus of the study was MALE RPAS that operate at altitudes above FL150. Two sets of cases were considered: Coastal patrol flights around FL175 and border patrol flights around FL320. The conclusions of this study are based on the considerations of operational ATCOs and HF experts related to these operational cases. As such they only provide the ATCO’s perspective for the discussion, and are intended to contribute to the discussion between RPAS operators, regulators and ANSPs.

This study was carried out focusing on the perspective of the ATCO, and the impact on them in terms of HF. From this analysis, a number of discussion points have been drafted for consideration in establishing RPAS policy and for future regulations for RPAS manufacturers and operators, and also for ATCO training and licensing. The considerations in the table below are provided as an input to the ongoing discussion between regulators, operators and ANSPs to enable RPAS integration in the future (Table 2). These are recommendations based on the study that was carried out and form a basis for further investigation in the development of civil airspace policy and regulations.

Table 2 Policy considerations

RPAS operations	RPAS flights within controlled airspace should comply with all aspects of Class A airspace operations for IFR (or SVFR), in the same way as other aircraft. This applies to both the aircraft (e.g. equipment such as transponder, sense & avoid and ADS-B in the future) as well as the operator.
Training requirements for UAV pilots	RPAS pilots are expected to have a similar level of training as commercial or military aircraft pilots that fly within Class A controlled airspace. The training of the UAV pilots should include an aspect of training to familiarise pilots with civil airspace operations.
RPAS interaction procedures	The procedures for interactions with RPAS, either through radio communications, telephone links or datalink, should be clearly identified to ATCOs. This would include the clear definition of lost link procedures. If cross-border operations are required within European airspace it is recommended that standardisation of procedures is investigated.
ATCO training	Initial ATCO training should include the interaction with RPAS within their scenarios, both in theoretical and in simulator training. This should include

	both normal operations, using military examples of RPAS operational scenarios for example, and emergency operations (such as lost link).
Lost link exercises	Due to the infrequent nature of RPAS operations, and of lost link occurrences, lost link exercises should be included in the continuation training of ATCOs. This is intended to ensure sufficient familiarisation with how to deal with a lost link situation. This should also include the interaction with other aircraft in the airspace in response to the RPAS lost link.

5.1 Recommendations for further research

This study considered several scenarios with operational ATCOs that were related to expected operational opportunities for RPAS in the near future. In these cases, the expectations of the ATCOs were that the standards of the RPA, and the pilots, would be equal to or equivalent to other aircraft within Class A airspace. This effectively means that the RPAS pilot is expected to have completed either military or commercial pilot training (IFR). Currently for both the RPAS industry and military RPAS operations, research is being carried out to determine the level of training required for pilots, since it is suspected that a full pilot's licence may not be required for effective operation of the vehicle.

It is therefore recommended that the HF impact on ATCOs be assessed for the situation where RPAS pilots have a simpler level of training, for example equivalent to a PPL or a simple pilot's licence. The research should address the aspects of the ATCO competencies that are affected, and how this can be mitigated – through training, procedures or systems requirements for example.

6 Final Remarks

The authors of this study had the opportunity to work with two groups of ATCOs in the Netherlands – military and civilian – to examine the likely impact of the introduction of RPAS on their tasks. This study is becoming more relevant as the demand to operate RPAS within controlled airspace increases, and ATC policy for RPAS is being developed.

The primary HF impact on the ATCO is from the type of mission that RPAS are likely to carry out, rather than the fact that the aircraft is unmanned. For example, it could be envisaged that coastal, or border patrol flights could be carried out more frequently by an RPAS than is currently the case. The impact of RPAS operations in emergency situations, such as a lost link, may also have a wider effect on the ATCOs, and their task than a comparable situation with a commercial aircraft. It was suggested by the ATCOs involved in the workshops, that if the RPAS pilots are trained to a level that is equivalent to the pilots of other aircraft in controlled airspace, the HF impact on the ATCO's task is limited. Though this may be the case, it is nevertheless interesting, from the perspective of the RPAS industry, to consider the case of RPAS pilots that are trained to a lower level than commercial pilots.

However, this study has also identified that there is a possibility that knowing the aircraft is unmanned and that the pilot is not on board could have psychological effects on controllers. ATCOs indicated that they would have the tendency to include an additional safety buffer (such as increasing separation) and direct more attention to RPAS. There is currently a feeling of unfamiliarity and mistrust with the concept of an RPAS operating within controlled airspace. If this would remain, the integration of RPAS would have an impact on controller's workload and situation awareness, especially as the number of RPAS increases.

The integration of RPAS within controlled airspace should therefore be carefully phased in, and exercises should be included in ATCO training to familiarise controllers in interacting with RPAS pilots, and the capabilities of the aircraft.

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