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12 Critical abilities required to the training of RPA MALE operators in the French Air Force: “working towards zero accidents in drones piloting“

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Abstract

The current study focused on the use of the Harfang in the French Air Force. This Medium Altitude Long Endurance Remotely Piloted Aircraft (MALE RPA) is integrated in air traffic and is managed by a three-specialists crew: a RPA Pilot (RPA pilot), a Tactical Coordinator (TC) and an Imagery Analyst (IA). The quality of Situational Awareness (SA) at both individual and crew level is a determining factor for safety.

We considered that building an optimal SA is strongly influenced by the development of competencies during training. As the training efficiency can be improved by an adapted selection of candidates, our study aimed to define the optimal profile of each Harfang specialist in order to select the best candidates' profile. A preliminary step was to compare the optimal profile (assessed by job analysis surveys) to the current profile of operators (assessed by psychological tests), to consider the efficiency of the training. Because candidates have not yet developed specific competencies, we made a comparison of profiles in terms of abilities. We identified cognitive and socio-emotional critical abilities which are required to the development of each Harfang specialist competencies. We adapted and applied the Fleishman Job Analysis Survey (F-JAS - Fleishman, Quaintance, & Broedling, 1984) to the whole population of Harfang operators (N = 30) who had to define the optimal profile of each specialist. Then we used visuospatial tests and personality inventory to assess the level of critical abilities identified with the F-JAS.

Results showed global consensual optimal profiles for each Harfang specialist. This means that the population of operators identified the same critical abilities needed to become a competent operator. Results to visuospatial tests confirmed that operators required the critical abilities identified by the F-JAS. But, we observed some interindividual variability which may have an influence on the efficiency of training.

A selection based on the assessment of critical abilities will reduce the interindividual variability and will facilitate the training standardisation. In fact, this standardisation is necessary to reduce the human error and then will improve safety.

Introduction

The French Air Force RPAS is an unarmed Medium Altitude Long Endurance (MALE) system, which contributes to control the battlefield by doing Intelligence Surveillance Reconnaissance (ISR) missions. These air vehicles are remotely controlled by operators located in a Ground Control Station (GCS). Called Harfang, these drones are 9m long and 17m wingspan, flying at an altitude of 6000 m, and are comparable to an aircraft with the difference that take-off and landing are automated. Its autonomy ranges up to 24 hours. The Harfang is managed by a three-specialist crew: a Remotely Piloted Aircraft Pilot (RPA pilot) which controls the aircraft and the payload (camera for day and night operations, with electro optical and infrared capabilities), an Imagery Analyst (IA) who performs image processing and real time videos, and a Tactical Coordinator (TC) leading the mission and coordinating the crew activity.

The job conditions of operators are very specific (e.g. crew organisation, lack of information concerning the aircraft status for the pilot) and therefore should have an impact on the building of a Situation Awareness (SA). By Situation Awareness (SA) we mean “knowing what is going on around one...what the aircraft is doing all times, both externally (e.g., turning) and internally (e.g, oil pressure)” (Martinussen & Hunter, 2010, p.200). For a better understanding of these job conditions and their impact on the construction of competencies, our method involved several steps.

Firstly, we need to understand precisely what the jobs of RPAs operators are by performing a Job Analysis which is “the prerequisite for any effective intervention” (Leplat, 2004, p. 107). We choose to conduct a dual job analysis, that is (1) directed towards the comprehension of the work (situational factors), and (2) focused on the capacity of the individuals (individual factors) as recommended by Spector (2006). The construction of competencies is based on abilities (Roe, 2002), that is why our study focused on these characteristics, namely the cognitive, socio-emotional abilities. Because abilities are less dependent on situations and practices, “the measure of individual ability ... is needed ... whenever working conditions make it difficult to acquire a specific skill because ... the work environment is changing ... so fast that the experience cannot create reusable skills” (Lévy-Leboyer, 2004, p.30). Thus, an approach based on the study of abilities offers a taxonomic system that is likely to be stable in a changing environment (Voskuil, 2005). Moreover, according to Hedge and al. (2006) and Roe (2002), the presence of appropriate abilities is related to the final levels of performance that an individual can achieve. In terms of core abilities, we consider these latter characteristics as factors facilitating or restraining the learning processes by which competences are developed, and so these abilities would be discriminative for a future selection.

Secondly, our aim was to assess a current and valid operator’s profile in order to identify a benchmark for the future selection process.

1 Method

1.1 Optimal profile

Participants

- 1) Preliminary to the adaptation of F-JAS to the RPAS population, 11 operators (10 men, 1 woman) from the unique RPAS squadron of the French Air Force (FAF) were interviewed (3 TC, 4 Pilots, 4 IA) to define the activity list for each job. They are considered as experts that is to say “people with knowledge and direct knowledge of their job” (Fleishman, 1995/1998, p.5) because of their experience in these functions (3 to 7 months on external operations at Bagram).
- 2) For the adaptation of the Fleishman’s questionnaire, three judges were solicited. They are employees of the Air Force and have a good knowledge concerning the job into the Ground control Station.
- 3) For passing the JAS-RPA’s Operators inventory, the entire population of the French RPAS Squadron was solicited via a secure and personal connection on the French Air Force intranet (30 participants at the end of 2010).

Procedure

The job analysis identifies the activities realized by the operator to perform the task (Leplat, 2004), which are referring to abilities (Snow, 1992): complex cognitive and socio-emotional abilities. These abilities are likely to explain performance, constitute the foundation skills and facilitate the development of these skills (Fleishman, Quaintance & Broedling, 1984).

1) Firstly, two documents were used as support for the interviews with operators. The first, adapted from a document from the French Air Force Headquarters, describes the stages performed during a standard mission of “MALE RPAS”. The second document is a list of criteria describing the complexity of the activities carried out: frequency, criticality (severity of consequences for failure), implementation difficulty, and learning difficulty. This selection of criteria is based on the description given by Moscato (2005). Following the recommendations of the Fleishman and Reilly’s manual (1992/1993), tasks were grouped into general component of tasks. The interviews had an average duration of 1h30mn then were transcribed, analysed, segmented and recombined in components of meaningful activities for each specialty.

2) In our approach of dual job analysis, the objective was to establish links between these key components and abilities. Then, we used the F-JAS1 (Fleishman & Reilly, 1992/1993) which consists of a list of 52 abilities related to cognitive, perceptual, psychomotor and physical sphere, and the F-JAS2 which is composed by 21 qualities relating to the interpersonal and social spheres (Fleishman, 1995/1998). Secondly, three judges assessed individually the opportunity to select or not these abilities in relation with activities. When there was consensus for the 3 judges, the ability was systematically kept in the final survey. If an ability was chosen by only one or two judges, a discussion began between the three judges to decide the relevance of the ability for the components.

3) Thirdly, we adapted questionnaires developed by Fleishman, Quaintance and Broadling (1984), in order to assess the required level of abilities: 86 for the RPAs Pilot, 92 for TC and 79 for IA, for a dozen of complex activities, with a 7-points-Likert scale. All operators have assessed the level of abilities required to be effective in various complex activities. In the instructions, we asked them to assess the level of complexity for the abilities required to do an efficient job as RPA's operators. Thus, such an assessment avoids the social desirability bias. Consequently, the profile defined by the JAS-RPAS is an "optimal" profile of the RPA's operators.

1.2 Current profile of operators

The objective of this experimentation was to identify the real profile of RPA systems operators in terms of cognitive spheres, especially the visuo-spatial sphere and the socio-emotional domain.

Participants

The sample was composed by 30 operators:

- 12 Harfang's Pilots, including a personnel of reinforcement.
- 8 TC officers, including a personnel of reinforcement. These officers are all intelligence specialists.
- 10 noncommissioned officers IA.

Construction of an experimental battery of tests

According to Martinussen and Hunter (2010, p.76), "The results from a job analysis may be used to select specific tests to be applied in the selection process and also to select appropriate criteria of work performance that could be used in a validation study". Table 1 shows the different tests we choose according to the nature of abilities assessed.

Table 1. Tests selected in the battery for abilities assessment

Sphere	Abilities	Test Selected or Predictors
Cognitive	Selective Attention	D2 Focused Attention - Brickenkamp, R. (1962).
Cognitive	Perceptual Speed	Identical Shapes - Thurstone L.L. (1958)
Cognitive	Spatial Orientation	Guilford-Zimmerman – (1989)
Cognitive	Visualisation	NV7-T subtest Spatial Visualisation – Bernaud, J.-L. et al. (1994)
Cognitive	Flexibility of Closure	GEFT Witkin Test Witkin et al. (1971)
Socio-emotional	Self-Control	Self-Control facet – OCEAN - Congard, A et al. (2012).
Socio-emotional	Perseverance	Perseverance/reliability facet – OCEAN
Socio-emotional	Reliability	Perseverance/ reliability facet – OCEAN
Socio-emotional	Sociability	Sphere of agreeability – OCEAN
Socio-emotional	Social Conformity	Social Desirability Score – OCEAN
Socio-emotional	Assertiveness	Leadership/Assertiveness facet – OCEAN
Socio-emotional	Organisational Skills	Organisation/scrupulousness facet - OCEAN

According to the visuo-spatial representation proposed by Carroll (1993), we assessed several factors with our battery of tests: 1) Visualisation with the NV7-T test, 2) Flexibility of Closure with the GEFT Witkin, and according to Lohman (1979) 3) Perceptual Speed with the test of Identical Shapes.

For the socio-emotional abilities, we used a new assessment inventory (OCEAN test) specific for the recruitment for officers and non-commissioned officers for all the French Armed Forces (Congard, Antoine, Gilles, 2012).

2 Results

2.1 RPA Pilot

In the French Air Force, the RPA pilot is both in charge of the aircraft and the payloads. This aspect can be considered in terms of cognitive aspects as a double-task. His actions may have serious consequences on the Aviation Safety. With our JAS tool, we connected, for instance, Selective Attention with the activity of “piloting and control the payload in order to track a target, setting the aerial vector, control the parameters”, Perseverance with the activity “which consist to be focused on the video during many hours”, Assertiveness with the “work in a team”.

Table 2. Mean Scores and Standard Deviations for Abilities in RPA's Pilot Optimal and Current Profiles. Deviation indicates the difference between the mean score of Optimal and Current Profiles. The optimal profile was assessed with the F-JAS and the Current Profile with the battery of tests

Sphere	Abilities	Current Profile		Optimal Profile		Deviation
		Mean Score	SD	Mean Score	SD	
Cognitive	Selective Attention	4.47	1.02	5.50	0.80	-1.03
Cognitive	Perceptual Speed	6.01	0.87	5.33	1.16	+0.68
Cognitive	Spatial Orientation	5.63	1.42	5.08	0.90	+0.55
Cognitive	Visualisation	3.63	0.43	4.92	0.90	-1.29
Cognitive	Flexibility of Closure	6.25	1.03	4.83	1.11	+1.42
Socio-emotional	Self-Control	3.92	0.67	5.67	1.07	-1.75
Socio-emotional	Perseverance	5.62	0.61	5.25	1.14	+0.37
Socio-emotional	Reliability	5.62	0.61	5.17	0.72	+0.45
Socio-emotional	Sociability	4.32	0.90	5.08	0.67	-0.76
Socio-emotional	Social Conformity	4.45	0.39	5.08	1.16	-0.63
Socio-emotional	Organisational Skills	5.12	1.37	4.67	0.98	+0.45
Socio-emotional	Assertiveness	5.02	0.94	4.58	0.79	+0.44

Comparisons between optimal and current pilot profiles showed a great variability. In fact, 5 of the 12 current profile mean scores are lower than optimal profiles mean scores. The deviation ranged from -1.75 (Self-Control) to +1.42 (Flexibility of Closure). Concerning the current profile, most of the mean scores are high and standard deviations showed some homogeneity. This homogeneity was expected as 83 % of the Harfang’s pilots came from the Fighter career (pilot or navigator).

These results can be interpreted as a partial matching between the Harfang’s pilot profile and the aircraft pilot profile, as current Harfang’s pilots are former fighter pilot or fighter navigator. Then, current Harfang’s pilots are certainly overqualified according to specific competencies requiring abilities like Flexibility of Closure or Perceptual Speed but it is important to note that these experts are underqualified according competencies requiring some cognitive abilities (i.e., Selective Attention) as well as socio-emotional abilities (i.e., Sociability).

In this study, some abilities were not yet assessed for the current profile. For the RPA’s pilot, it is the case for instance in the Psychomotor Sphere (Movement Timing, Control Precision Movement, Arm-Hand Steadiness). Indeed, we chose not to assess these abilities because (1) we focused on cognitive abilities and (2) psychomotor skills are so strongly linked to ergonomics aspects. In fact, Harfang’s GCS is not up to date and the current interfaces and their operational limitations should be resolved in the future.

2.2 Tactical Coordinator

The TC is considered as a Mission Commander into the crew. He manages both the RPA's pilot and the IA, supervised and transmits tasking and retasking and is responsible for maintaining the vigilance of the crew. He prepares the mission, sometimes with the Liaison Officer of the Task Force. With our JAS tool, we connected for instance Selective Attention with the activity of "analysing and optimising the data coming from different Information Systems (e.g. chat) ", Assertiveness with the activity "conducting briefing/debriefing with all the concerned personnel ", and Sociability with the activity "working efficiently the crew (Imagery Analyst, and Pilot, Intelligence personnel, Liaison Officer...), the retasking, the dull situation".

Table 3. Mean Scores and Standard Deviations for Abilities in TC Optimal and Current Profiles. Deviation indicates the difference between the mean score of Optimal and Current Profiles. The optimal profile was assessed with the F-JAS and the Current Profile with the battery of tests

Sphere	Abilities	Current Profile		Optimal Profile		Deviation
		Mean Score	SD	Mean Score	SD	
Cognitive	Selective Attention	4.79	0.67	5.44	1.24	-0.65
Cognitive	Spatial Orientation	3.80	1.92	5.44	1.13	-1.64
Cognitive	Perceptual Speed	5.76	0.96	5.00	1.00	+0.76
Cognitive	Flexibility of Closure	4.52	2.13	4.89	1.45	-0.37
Cognitive	Visualisation	2.92	0.65	4.67	1.00	-1.75
Socio-emotional	Reliability	5.58	0.73	5.67	1.00	-0.09
Socio-emotional	Assertiveness	5.18	0.89	5.56	0.73	-0.38
Socio-emotional	Self-Control	3.50	0.72	5.22	0.67	-1.72
Socio-emotional	Perseverance	5.58	0.73	5.22	0.83	+0.36
Socio-emotional	Organisational Skills	4.80	1.38	5.22	0.97	-0.42
Socio-emotional	Sociability	4.50	0.7	4.89	0.60	-0.39
Socio-emotional	Social Conformity	4.55	0.88	4.11	0.93	+0.44

Table 3 showed results in the Tactical Coordinators' population. Current profile mean scores were less frequently higher than optimal profiles mean scores. The only cognitive ability concerned is the Perceptual Speed (+0.76) whereas Tactical Coordinators were obviously underskilled in Visualisation (-1.75), Self-Control (-1.72) and Spatial Orientation (-1.64). Nonetheless, mean deviations between current and optimal profiles mean scores were weak as well as standard deviations in the current profile.

Some activities in Tactical Coordinators are part of Air Traffic Control activities (e.g. clearance). The large deviations due to lower mean scores in Visualisation and Spatial Orientation of the current profile compared to the optimal profile may be explained by the fact that Tactical Coordinators are former Intelligence Officers. Indeed, Intelligence Officers are not trained for Air Traffic Control. Nevertheless, we can interpret these results as a fair matching between the optimal profile of Tactical Coordinators and their current profile as former Intelligence Officer.

2.3 Imagery Analyst

The IA is an Intelligence Personnel in charge of analysing both the video and the images of the Harfang. In French Air Force he is not in charge of the payload, but he is discussing with the RPA's pilot in order to choose the best angle of observation. However, he is in charge of the management of the Synthetic Aperture Radar (SAR) occasionally used in case of bad weather. With our JAS tool, we connected for instance Visualisation with the activity of "Capturing, analysing images", Sociability with the activity "Communicating efficiently with the team", and Self-Control with the activity "Handling stressful situation, exposure to combat-related events (e.g. Troops In Contact (TIC), Improvised Explosive Device (IED), rocket-launcher)".

Table 4. Mean Scores and Standard Deviations for Abilities in IA Optimal and Current Profiles. Deviation indicates the difference between the mean score of Optimal and Current Profiles. The optimal profile was assessed with the F-JAS and the Current Profile with the battery of tests

Sphere	Abilities	Current Profile		Optimal Profile		Deviation
		Mean Score	SD	Mean Score	SD	
Cognitive	Spatial Orientation	3.87	1.45	5.33	1.73	-1.46
Cognitive	Visualisation	3.62	0.58	5.22	1.30	-1.60
Cognitive	Flexibility of Closure	5.99	1.13	5.22	1.48	+0.77
Cognitive	Selective Attention	4.81	0.82	5.00	1.50	-0.19
Cognitive	Perceptual Speed	6.41	0.46	4.67	1.50	+1.74
Socio-emotional	Perseverance	5.70	0.83	4.89	1.45	+0.81
Socio-emotional	Assertiveness	4.10	1.03	4.89	1.54	-0.79
Socio-emotional	Organisational Skills	5.06	1.54	4.89	1.54	+0.17
Socio-emotional	Self-Control	4.32	0.77	4.67	1.32	-0.35
Socio-emotional	Reliability	5.70	0.83	4.67	1.22	+1.03
Socio-emotional	Sociability	4.84	0.79	4.67	1.32	+0.17
Socio-emotional	Social Conformity	4.90	1.29	4.33	1.58	+0.57

Table 4 showed results in the Imagery Analysts' population. Standard deviations of the current profile showed a weak variability but which is greater for the optimal profile. The matching between the optimal and current profiles suggested that Imagery Analysts were underqualified in some abilities and overqualified in some others. They seemed to have some weaknesses in Spatial Orientation (-1.40) and in Visualisation (-1.60) whereas they showed a great performance in Perceptual Speed (+1.70). These results can be explained by the specificity of imagery processing in MALE RPAS. Imagery Analysts in a MALE RPAS are asked to assist the pilot in the camera handling in order to collect the most useful video stream whereas they were only trained to analyse pictures before their Harfang enlistment.

The great variability for the optimal profile may be influenced by a lack of practical experiences because 2/9 Imagery Analysts are newly graduated just before enlistment into the Harfang squadron, another 2/9 have no practical experience on Harfang (only theoretical knowledge), 1/9 did only one external operation at Bagram, so we can consider that the group is composed by 4 different types of specialists. Consequently, Imagery Analysts, according to their own experience, assessed differently the level of complexity of crucial abilities.

In this study, some abilities were not yet assessed for the current profile as some perceptive abilities (Near Vision, Night Vision) which are dependant of ergonomics aspects and medical requirement.

3 Discussion

The ranking of critical abilities varied according to the Harfang's jobs. Spatial Orientation and Visualisation were the highest abilities assessed by Imagery Analysts, Reliability and Assertiveness by Tactical Coordinators and Selective Attention and Self-Control by Pilots because each job requires specific abilities.

As expected, no large deviations were observed between the optimal and the current profiles. In fact, all the operators were trained and qualified for the Harfang's system.

The main objective of our study was to highlight mismatches between the two profiles to identify strengths and weaknesses of the current profiles. Then, a profile diagnosis for each job may be useful to determine future improvements of the MALE RPAS Operators. Thereafter, the battery of tests would be used to define individual diagnosis which will be included in the selection process, preliminary to a modular and specific training. Nevertheless, our results have to be confirmed considering the major issue of the creation of a RPAS career field in the French Air Force.

A high-value ecological test is under construction related to the dual-task paradigm for the assessment of Divided Attention and Auditory Attention abilities, which were none yet integrated in this study.

The use of civilian tests like the Identical Shapes (Thurstone, 1958), the GEFT Witkin Test (Witkin et al., 1971) implies several modifications to adapt the tests meant to select military applicants. By example, calibration of tests would consider the characteristics of a military population who is likely to be enlisted in a MALE RPAS squadron. Currently, we collected data to constitute a calibration of the MRT 0-4 (Vanderberg & Kuse, 1978; Peters et al., 1995, modified by Glück & Fabrizii, 2010) with French Air Force Cadets. However, the personality test we used raised a mismatch for the Self-Control assessment. The deviation between the optimal and the current profiles may be due to a difference in the Self-Control representation. Namely, operators may have considered Self-Control in the F-JAS (i.e., optimal profile) as the ability to control and contain their emotional reactivity (e.g., anger, fear) whereas the OCEAN personality test (i.e., current profile) seemed to assess more the hot-tempered trait than the ability to contain emotions.

Finally, our results showed that socio-emotional abilities should not be considered as minor abilities. High level of socio-emotional abilities are required in a MALE RPAS all the more so collaborative work will be more and more central in the future MALE RPAS particularly in the military intelligence domain. Some studies will be useful to find the optimal procedure to efficiently manage a team composed by pilots and non-pilots. Furthermore, the use of RPAS in network centric operations involves to develop an operative language and to use secure transmission systems, especially with a crew composed by various specialists. To develop a common culture and efficient interactions, they must acquire a specific operative language in order to reduce the risk of error in decision making. The development of this specific language is related to such abilities as Auditory Attention, Recognition Speech, Oral Expression, or Oral Comprehension, all evaluated at a high level by RPA operators. So the future selection and training process of RPAS operators will gain to integrate our flexible and diagnostic abilities's approach in order to ensure more standardisation and thus greater efficiency of the crew and Aviation safety.

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