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Executive summary

Evaluation of Required Ground Pilot Competencies for Personal Air Transportation

Problem area
The PPlane Project (Personal Plane), initiated by the European Union's Seventh Framework Programme, aims at developing operational concepts to enable individual air transport. The objective of such an operational concept is to avoid the ever increasing congestion on European roads and to offer an alternative for the current transport system in the European Member states.

Different concepts are explored, from ground pilots that manually control one PPlane up to ground pilots that control multiple fully-automated PPlanes. When it comes to using the specific technologies in an automated setting, certain competencies are required from the operator (ground pilot) of the system. This paper presents a validated high level competency profile as well as the process on how the competence profile for a possible future operational concept and job function was developed.

Description of work
The following research method is used to explore the required human competencies:

- Analysis of several related and relevant competency profiles and discussions between experts. This resulted in a first competency profile draft.
- A PPlane survey in which the first competency profile draft was presented and evaluated in relation with different PPlane concepts and scenarios. This resulted in a second competency profile draft.
- Experimental set-up to test different scenarios for the most automated concept. In this concept one ground pilot controlled multiple fully-automated PPlanes. During the experiment the Human-Machine Interface (HMI) and the competencies of the second competency profile draft were observed and evaluated.

Results and conclusions
This approach resulted in a final competency profile for the ground pilot. This competency profile provides a strong basis for the PPlane concept and technical design in the light of physical, mental and behavioral properties and capabilities (Human Factors).

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This report is based on a presentation held at the AUVSI 2012 conference, Israel, 20-21 March 2012.

Evaluation of Required Ground Pilot Competencies for Personal Air Transportation

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Contents

1 Introduction

The PPlane (Personal Plane) project aims at developing operational concept ideas to enable individual air transport. The objective of such a concept is to avoid the ever increasing congestion on European roads and to offer an alternative for the current transport system in the European Member states.
The idea is that a PPlane offers inter-city personal air transport that will carry two to four passengers between cities. PPlane is designed to be a highly safe and secure mode of transportation with a low environmental impact. It flies for relatively short distances of a few hundred kilometers. Two separate operators are involved in the PPlane concept. The passenger in the airplane itself forms the PPlane Passenger. The PPlane Passenger has control of the PPlane like a passenger in nowadays taxies. The PPlane passenger provides the desired destination or specific driving request. The driver is responsible for getting the passenger where he wants. In the PPlane concept this role of (taxi)driver is performed by a PPlane operator, the Ground Pilot (GP) that controls the plane from the ground. Compared to nowadays-private jet services this means that the pilot controls the airplane from the ground instead of from on board the plane.
This paper presents a part of the Human Factor (HF) work within the PPlane project. It explores the required competencies of the PPlane GP in charge of operating the highly automated PPlane system. The following research question was examined:

'What are the required competencies of a PPlane GP and how are these competencies organized and classified with regards to essentiality for future job performance?'

Within this research competences are defined as an integrated set of skills, knowledge, attitudes, personal traits and background which enables the operator to perform his / her function in a certain context as described by van der Pal and Abma (2009-1). According van der Pal and Abma "the skill, or set of skills, is the core of the competency. In this model an attitude or knowledge does not constitute a competency on its own. This definition clearly links the competency to skills", see Figure 1.

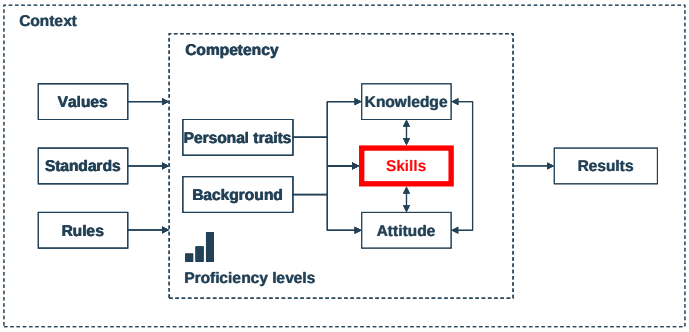

Figure 1 NLR competency model

The desired outcome of this particular study is a tested and evaluated high-level competency profile. The competencies for functioning as GP form the main foundation for the training design (van der Pal and Abma, 2009-2) and job selection. This competency profile provides also a strong basis for the PPlane concept in the light of physical, mental and behavioral properties and capabilities of the GP.

This paper starts with describing the research method used. It addresses how the first competency profile draft came about, how this profile draft has been evaluated and updated by means of a survey and how it has been tested in an experimental setting. The paper concludes with an evaluation and discussion of the results.

2 Exploration and research method

The concept of research followed to answer the leading question is summarized in Figure 2. The upper boxes are part of the primary exploration to come to a first competency profile. The validation box at the bottom represents the research through the survey and experiment.

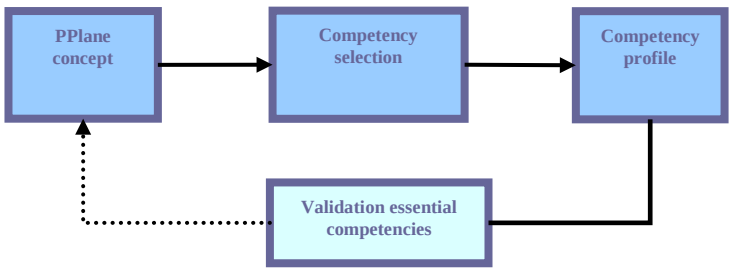

Figure 2 Relation between competency profile and PPlane concept

2.1 Exploration

Several relevant competency profiles of related professions have been analyzed and used to compose a first draft of the GP's competency profile. A schematic reproduction of competencies that are recognizable, accepted and sufficiently detailed in order to deduct a training design or a set of selection requirements is called a competence profile. Such a profile has a hierarchical structure and exists of main competencies, sub, supporting, essential competencies and attitudes. The following professions were selected for analyses:

Remote pilot: the relevance of this profession is the unmanned aircraft, which is piloted remotely. Roos (2009) did a UAS remote pilot station manning study in which a task analysis and an analysis of the competencies have been performed. McMillan et al (2010) studied the psychological profile of the UAV controller.

Air Traffic Controller (ATCo): the relevant aspect of this profession is the monitoring of several entities in a 4-dimensional environment. Van der Pal (2007) concretized the competency profile for the fighter controller.

Fixed and rotary wing pilot: relevant aspects are knowing the effects of controls on the air vehicle and maintaining situation awareness. Abma et al (2010) studied the competency profile for the Air Force pilots.

Emergency dispatcher: the relevant aspect of this profession is dealing with critical situations from a distance. Meijer (2000) performed his thesis on the tasks of an emergency dispatcher.

The question asked was which of the competencies within these profiles fit the PPlane GP competency profile? The main focus was on the required skills and attitudes and this resulted in the first draft of the PPlane GP competency profile, see Figure 3.

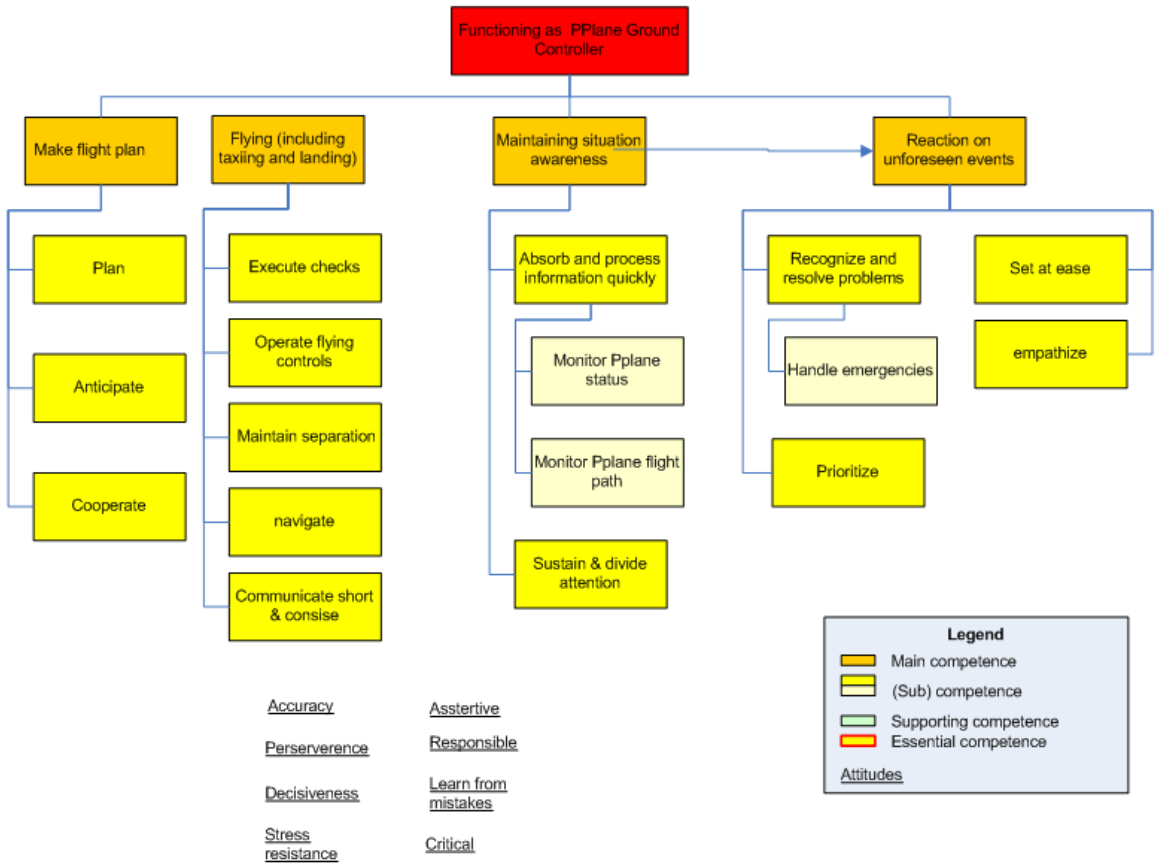

Figure 3: First competency profile draft PPlane GP

This competency profile is a hierarchic structure that reflects the full job. Certain skills or competencies may not fit in the hierarchy as they support a variety of higher order competencies. Such competencies are labelled ‘supporting’. Certain skills or competencies may be recognized as vital to the execution of the task. Such competencies are labelled ‘essential’ (van der Pal and Abma, 2009-3). The labelling of the different competencies in this research is done during the different validation rounds.

2.2 Research methods

The first competency profile was validated following two consecutive steps of research:
Validation round 1: a PPlane digital survey in which the first competency profile draft was evaluated in relation with different PPlane scenarios. This resulted in a second competency profile draft.
Validation round 2: experiment to test different PPlane scenarios. During the experiment the competencies of the second competency profile draft were observed by means of a checklist

with observable behavior criteria and evaluated by means of discussion and a post-run survey. This resulted in a final competency profile for the GP.

3 PPlane Digital Survey (validation round 1)

During this research we used a highly automated concept to study the competencies, see Figure 4.

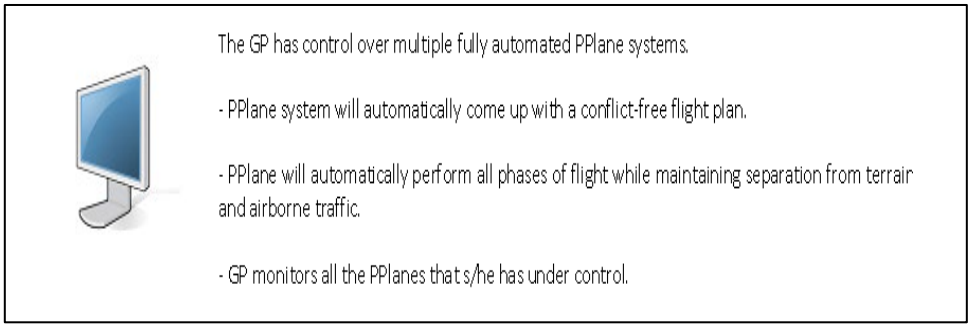

Figure 4: operational PPlane concept FOR competency research

The PPlane participants were asked to select five skills and three attitudes that are supposedly essential for the GP. Essential competencies are characterized by their difficulty, importance for succeeding the task and how frequent they are used. In order not to guide the respondents the competencies and attitudes were offered in a random list. To get a common understanding of the competencies a definition had been developed for each skill and attitude. These definitions were available by mouse-over.

The number of invited participants for this survey was 253 of which 120 fully responded and 23 partially. This gives a response rate of 56.4%. The average age of the respondents is 42 years, and 55% of the respondents live in the Netherlands, 21% in France.

4 PPlane Experiment (validation round 2)

A PPlane simulation environment (including the HMI for the GP, see Figure 4) was developed for an experimental study. One of the objectives of this study was to validate the (second) competency profile resulting from the survey.

4.1 Experiment set-up

Icons representing PPlanes were visible on a map of the area. Blinking items represented PPlanes with requests. By clicking on a PPlane icon, its planned route and additional flight information became visible on the map and a communication window was opened to communicate (via text message / chat) with the PPlane Passengers. Besides text messaging, the GP could communicate via voice (using a headset) to the different actors involved (e.g. passengers, ATCo, other GPs). A large wall displaying all PPlanes under control was available together with an action item list to help in the prioritisation of actions. The GP had available a regular mouse and keyboard for inputs to the system. Herewith, the GP could interact with the overview map (i.e. selecting PPlanes, zooming in/out the map). In addition, the GP had a 3D mouse available to control the PPlane (i.e. changing heading, speed, moving waypoints).

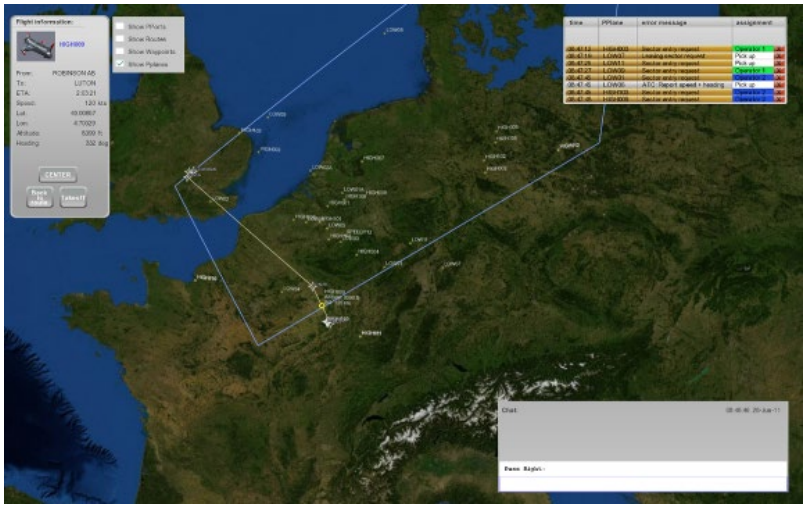

Figure 5: GP user interface

4.2 Experiment actors

The following actors participated in the experiment:
GP: the GP's were the main focus of research for this experiment. In the experiment a team of two GP's were controlling approximately 30 PPlanes in the area of operation. Their tasks included:
Communicating with Air Traffic Control (ATC) for take-off and landing clearances
Giving a go for the take-off (after receiving clearance from ATC)
Checking handovers of PPlanes from and to another area
Talking to PPlane Passengers, handling requests, setting them at ease
Handling problems and/or emergencies. In that case s/he had to:
Talk to ATC
Take care of emergency procedures (using checklists)
Find nearest airport (re-routing) in case of emergency landing
Talk to operators in case of failures
Detect and solve problems with other traffic
Alert emergency services in case of emergency landings
Passengers: the experiment leaders simulated the passengers
ATC: the role of ATC was limited to take off and landing clearances and emergency situations. The experiment leaders played ATC.

To validate the selected competencies the experiment leader observed the GP's in an experimental setting. To create a common understanding of correct performance, a set of observable behavioural criteria belonging to the different competencies was developed using existing assessment lists and feedback from subject matter experts within NLR. Those criteria gave information about the difficulty, the importance and the frequency of the different competencies under different circumstance. The observer rated the behaviour in four different ways, see Table 1.

N	U	F	G
Not graded /Demonstrate The action was not performed by the test person (machine action / responsibility not clear)	**Unsatisfactory /Unable** The action was performed unsafe due to lack of knowledge, skills or capacity	**Fair** The action was performed with some deviations due to a lack of skills but the test person corrected him/herself timely	**Good** The action was performed correctly, the level of knowledge, skills or capacity is okay

Table 1: Ratings used TO OBSERVE the GP's behaviour

N indicated that the underlying skill or attitude of this specific behaviour should not be part of the competency profile. U, F, or G are part of the competency profile. Note that it was not the intention to assess the participant. The objective of this experiment was to validate the competencies.

After the experiment the participants were asked to rank the most relevant skills and attitudes using the same digital survey that was used for validation of the first competency profile.

The number of participants for this experiment was 14. They were students between the age of 20 and 26 of which 7 of them had an engineering background, 6 an information science background and one had a background in journalism.

5 Research outcomes

5.1 PPlane Digital Survey outcomes

The results of the digital survey are given below. Table 2 and Table 3 show the top five skills and top 3 attitudes per concept.

1 Recognize &resolve problems
2 Absorb & process information quickly
3 Prioritize
4 Handle emergencies
5 Sustain & divide attention

Table 2: top 5 skills

1 Stress resistant
2 Accuracy
3 Responsible

Table 3: top 3 attitudes

See Figure 6 for the second competency profile draft as a result of the digital survey. This competency profile formed the basis for the experiment. Note that within this profile the supporting skill ‘cooperation’ has been added as a result of future concept expectations of the PPlane project members.

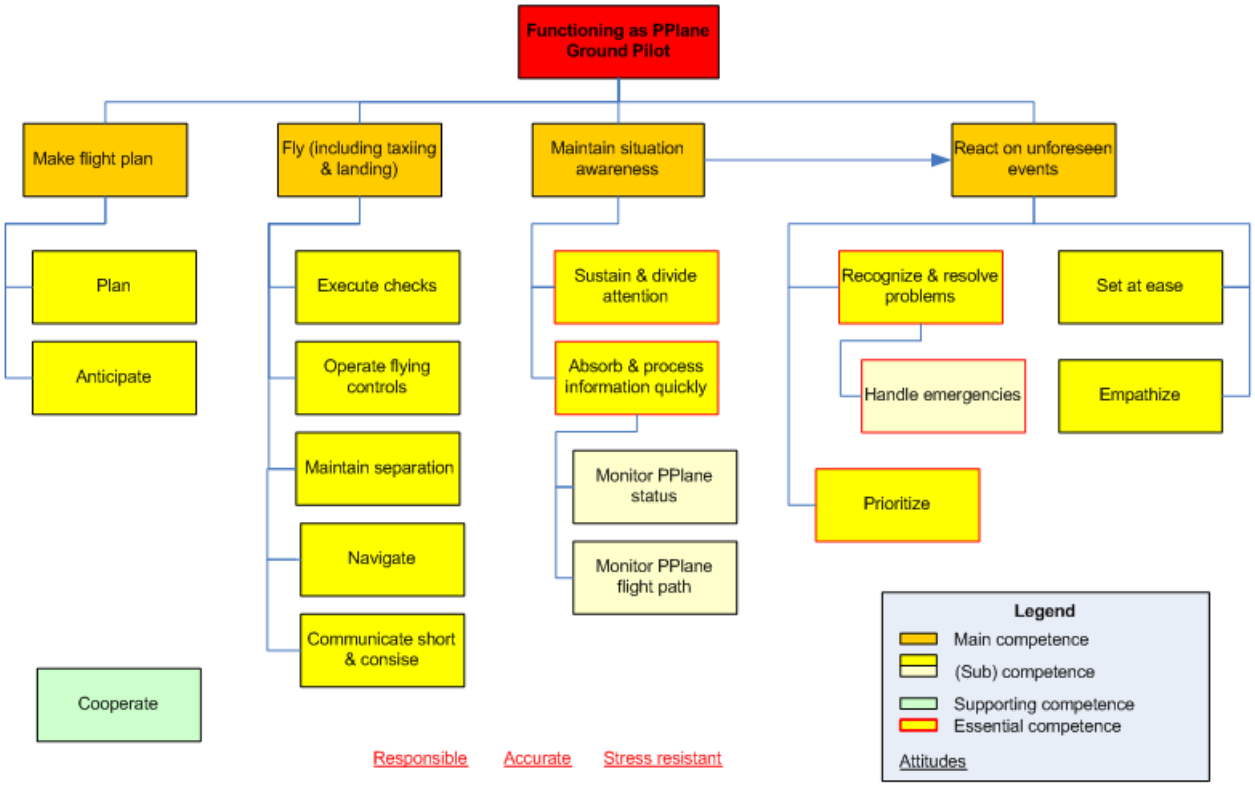

Figure 6: second draft of the PPlane GP competency profile

5.2 Experiment Results

The results of the expert observations (Table 54, Table 65 and 6) measured 7 out of the 9 observed skills and attitudes with a score above 75% and are therefore validated as essential.

Results			
	Predefined observable behaviour (total scores)	Rated N (%)	Rated U / F / G (%)
Sustain & divide attention	28	7%	93%
Absorb & process information quickly	28	14%	86%
Recognize & resolve problems	28	25%	75%
Handle emergencies	14	0%	100%
Prioritize	42	23%	77%
Cooperate	70	33%	67%
Responsible	28	21%	79%
Accurate	28	18%	82%
Stress resistant	70	66%	34%

Table 4: results experiment observation

The supporting skill ‘cooperate’ and the attitude ‘stress resistant’ scored below 75% and could therefore not be validated.
The post-run survey held directly after the experiment gave the following results for skills and attitudes in ranking order (i.e. mode value).

1 Prioritize
2 Anticipate
3 Cooperate
4 Absorb & process information quickly
5 Handle emergencies

Table 5: post-run survey top 5 skills

1 Stress resistant
2 Accuracy
3 Decisiveness

Table 6: post-run survey top three attitudes

Compared to the experiment observations there are two essential skills that were not validated by the experiment leader but that were validated in the post-run survey, namely: ‘anticipate’ and ‘cooperate’. With regards to attitudes the attitude ‘decisive’ was not taken into account during observations but ranked in the top 3 attitudes during the post-run survey.

The experiment outcomes on essential competencies resulted in the final competency profile, see Figure 7.

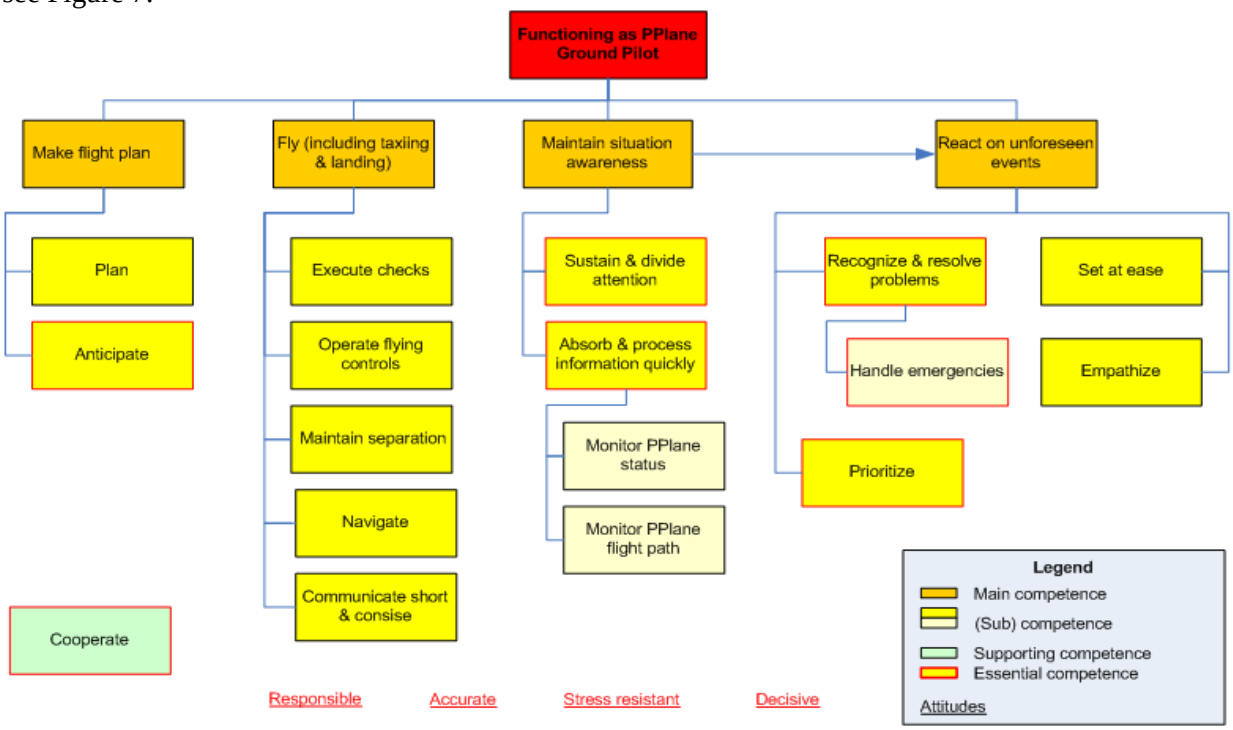

Figure 7: Final PPlane competency profile

The difference with the competency profile drafted before the experiment is the assignment of ‘anticipate’ and ‘cooperate’ to essential competencies and the assignment of ‘decisive’ to essential attitudes.

6 Conclusions and recommendations

Regarding the GP, not much experience was actually available as the role is quite new, although similarities seem to exist with the professions remote pilot of unmanned aircraft and ATCo. As an outcome of the inventory of different relevant competency profiles and numerous expert discussions, a first competency profile draft for the GP was developed. This draft was fine-tuned and validated by performing an online survey and experimental study. The fine-tuning primarily focused on the appointment of the essential competencies for functioning as GP because essential competencies are the main drivers for training design and job selection.

The digital survey (validation round 1), confirmed the notion that, in contradiction to remote pilot and fixed and rotary wing pilot competencies, the main competency ‘to fly the PPlane vehicle’ is not really an essential part of the GP role within the highly automated concept of the PPlane system. This notion is validated by the experiment because the participants did not have experience in resembling functions and still they were, after a short training, able to function as a GP. However, this does not mean that this main competency can be neglected. The GP should still have knowledge about the flight-specific characteristics of the (different) PPlanes. That is, such knowledge will support the execution of the essential skill ‘anticipate’ and main competencies ‘maintain situation awareness ‘and ‘react on unforeseen events’.

During the experiment (validation round 2), the competency profile that resulted from the digital survey was validated with observations and a post-run survey. During the observations almost all essential competencies were observed and validated with a rating score of over 75%, with the exception of the supporting skill ‘cooperate’ and the attitude ‘stress resistant’. With regards to ‘cooperation’ the most often used strategy of working together was ‘in turns’. Within the tasks there was no cooperation. The only cooperation was between tasks, thus “who is doing this task?

The post-run questionnaire results of the experiment on the other hand showed that the GP participants did feel that being ‘stress resistant’ was the number one attitude. And also ‘cooperation’ was part of the top 5 skills. This means that there was a contradiction in what the participants scored in the post-run survey and what the experts observed during the experiments.

This might be explained by the fact that observations and debriefing comments showed that there were not much stressful situations encountered. Another explanation might be that the participants did not have the notion of stress or need for cooperation because of their lack of experience or knowledge and therefore cannot oversee consequences of certain situations or actions. An experiment with more stressful situations and participants with remote pilot and/or ATCo working experience to possibly validate and analyse the attitude stress resistance and the skill cooperation would be interesting for future research.

The essential attitudes ‘accuracy’ and ‘decisiveness’ illustrated that GPs were expected to work correctly, precisely, exactly, to be certain and determined, and to show authority. Competencies like ‘set at ease’ and ‘emphasize’ were not considered essential as the participating GPs were expected to act professional (in accordance to the attitudes ‘accuracy’ and ‘decisiveness’) and were not keen on talking socially. These results were also in line with the suggestion of the participating GPs to close the direct line of communication with the passengers to prevent the passengers from contacting the GP with irrelevant issues such as questions about what the passengers are spotting now. In case of low task load situation, on the other hand, the participants indicate that it might be interesting and fun to be able to talk to the passengers.

The action item list that was part of the HMI seemed to help in prioritising the actions. Therefore, this turned out to be a very help- and powerful tool that helps to support the essential skill ‘prioritizing’. An important aspect of the action item list is that it should be flawless; otherwise, GPs may be misconducted and will end up neglecting this list.

Further discussions amongst the participants and within the WP4 team took place with regards to the essential attitude ‘responsibility’: who is actually responsible for the PPlane? The GP is indeed responsible for each PPlane within his/her sector. However, because of the high level of automation within the PPlane concept, the GP seems to be just an actor checking the automation to do its job correctly and informing different parties involved in case of an emergency. This places the GP in a function in which s/he is responsible, but has no real (direct) means to handle the situation when this is necessary. Also the lack of knowledge and experience can influence to feeling of not feeling responsible. This might explain why the attitude ‘responsibility’ is validated during observation but not rated as essential in the post-run survey. Not all participating GPs felt comfortable with such type of responsibility -which anyhow leaves the liability issue unsolved. A suggestion for future research is to find the answer to the following question: ‘What is the influence of not feeling responsible -i.e. feeling just an actor checking the automation- on the performance of the competencies, and how does this influence the operational PPlane concept?’.

The trend within the resulting competency profile seems to be that all essential competencies are aimed at ‘situation awareness’, and on top of that ‘reacting on unforeseen events’. This is in line with the observation that the GP profession seems to reflect an actor checking and working off the nominal events (using a high level of automation), reacting on unforeseen events (e.g. emergencies) and informing different parties involved. The competencies of the GP present a clear overlap with professions like ATCo and emergency dispatcher. The Remote pilot of unmanned aircraft and fixed and rotary wing pilot competency profiles contain also competencies that belong to ‘flying’. In the PPlane concept these are mainly enablers for ‘situation awareness’, and ‘reacting on unforeseen events’. Nevertheless some experience and deep understanding of those competencies are vital to make decisions and react in abnormal situations. There are also thoughts that the profile of gamers might somehow fit to the competencies of GP’s as games often triggers on situational awareness and reacting on unforeseen events in a dynamic environment without having the real operational skills. However the attitudes safety and risk management might be underdeveloped because these are not engrained like they are within aviation.

Summarizing, the profession of GP reflects a rather new role within aviation, although with clear overlap with professions like ATCo and emergency dispatcher. To become a GP an adequate training and proper licensing is indeed required. Candidate GPs should be selected based on the essential competencies that were the result of the underlying research. Nevertheless, more research on topics like responsibility, cooperation and stress resistance is needed before being able to design training, select future GP’s and support the PPlane concept design by means of a final GP competency profile.

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