Supporting Fighter Pilot Decision Making Through Team Option Awareness

Tove Helldin(✉) and Tina Erlandsson

School of Informatics, University of Skövde, Skövde, Sweden
{tove.helldin, tina.erlandsson}@his.se

Abstract. Fighter pilots must often make decisions fast, under time-pressure and based on uncertain or incomplete data. Thus, decision-making in this environment poses several challenges on the pilots such as how to fulfil the goal of the mission, while at the same time limit the potential costs and risks taken to fulfil this goal. Another challenge involves the dynamic coordination of actions within the team of pilots needed to succeed with the mission efficiently. This paper discusses challenges and opportunities of introducing a decision-support tool in the fighter aircraft, aiding the pilots determine the best course(s) of action with regard to the team's resources, opportunities and the possible risks involved. To do so, we apply the concept of *option awareness*, guiding the future development of decision support in the fighter aircraft domain.

Keywords: Decision support · Option awareness · Fighter pilots · Team decision making

1 Introduction

The development of decision-making tools has resulted in a myriad of support systems in a variety of domains – such as air traffic control and nuclear emergency response [1, 2]. These systems often aim at improving the decision makers' awareness of the situation and to make timely decisions under stress and uncertainty. Recent research has added to these studies, focusing on improving the decision makers' awareness of the available decision options and their consequences on future states [3, 4]. For example, Pfaff et al. [5, 6] have conducted studies exploring possible ways of improving emergency decision makers' awareness of their available options and the consequences of implementing these options on the current and probable future decision space. The authors define this phenomenon "option awareness", meaning the "*perception and comprehension of the relative desirability of the available options, as well as the underlying factors, trade-offs, and tipping points that explain that desirability*" [6] (p. 155). Pfaff et al. [6] further argue that the communication of available and, in some respect, most effective options can aid the decision maker identify the most robust options, i.e. the options that are less sensitive to uncertainties in the current and evolving situation. Moreover, the presentation of these options is to aid the decision makers understand why an option is considered better than another one, thus improving the decision maker's understanding of both the reasoning model of the decision support and the probable consequences of the different options. As such, the

D. Harris (Ed.): EPCE 2015, LNAI 9174, pp. 345–355, 2015.
DOI: 10.1007/978-3-319-20373-7_33

decision makers are provided with a better foundation for trusting the automated decision aid – something which has proven to be of great importance for efficient human-automation cooperation [7, 8].

In the fighter aircraft domain, we argue that there is much to gain by taking the concept of option awareness into account when designing support systems – both when designing mission planning systems as well as systems to be used during flight. By communicating the available options and their probable consequences, we believe that the resources of the individual pilots and the team of pilots as a whole can be better and more efficiently exploited. Moreover, the generation of different context-sensitive options can further aid the pilots balance different objectives during flight, such as to fulfil the goal(s) of the mission, to fly safely and to survive potential battles as described by Schulte's goal model [9]. In this paper, we elaborate upon the opportunities and challenges of designing decision support systems in the fighter aircraft domain where the pilots are aided with generating and projecting the most effective options.

2 Background

Much work has been conducted to aid decision makers in various domains make timelier and more efficient decisions. Improved situation awareness, i.e. the ability to perceive, comprehend and project critical factors in the situation [10], has often been pointed out as a viable factor for improving the decision making quality. Yet, it has been argued that understanding and being able to predict the situation is sometimes not enough to make good decisions – the decision maker must also be able to understand which decisions that will lead to a certain goal or situation and assess the probable costs of these decisions under all plausible circumstances. Hall, Hellar and McNeese [11] termed this leap from understanding the situation and knowing which decision is best the *"situation space – decision space*" gap. To bridge this gap, option awareness has been identified as a possible solution, where the decision maker is aided in his/her cognitive work of generating an overview of viable options and understanding the consequences of these options on the future situation space [6].

Studies of option awareness have been conducted within the emergency response domain (see for instance [5, 6]). In these studies, the participants were aided with deciding upon, for example, how many fire trucks to send to an emergency area, taking into account the immediate costs of sending these resources, likely property damage and the risk of causalities. The studies indicate that the generation and visualization of decision space options indeed resulted in that the decision makers identified the most robust options more often, that they made their decisions faster and with more confidence than the decision makers who only had situation space information [6]. To our knowledge, no such study has been conducted within the fighter aircraft domain. This domain is likely to pose new challenges on the generation of the most robust options. For example, in this domain there might be adversaries who want to inflict harm on the own forces, adding to the complexity and uncertainty of the decision making situation. Additionally, the decision time frame can be very limited, leaving sparse time resources to generate and evaluate possible options. Further, to communicate the decision space by visual means on the limited display space of the aircraft poses additional challenges on the chosen option representation. Moreover, the best option(s) most often involves the coordination of pilot team activities, placing large responsibility on the pilot team leader to assess the individuals' and team's resources, opportunities and weaknesses.

Literature regarding decision support for fighter pilots often delimits the scope to include a single pilot, not addressing the team perspective. However, fighter pilots interviewed in [12] considered team work to be an important key to mission success. Together the group of aircraft can carry more resources in terms of sensors and weapons. By sharing information within the team, the pilots achieve a better understanding of the situation than is possible when flying alone. It is argued in [13] that a decision support system that adapts its presentation and recommendations according to the current situation regarding the individual pilot as well as the team would aid fighter pilots to accomplish their mission. Turning to literature regarding unmanned aerial vehicles (UAVs), many examples of algorithms and procedures for cooperation can be found. This includes, for example, collaborative UAV area coverage [14, 15], border patrol [16], convoy protection [17], and distribution of medical supplies [18]. Although it is likely that much inspiration can come from the UAV literature, it is important to acknowledge the differences between manned and unmanned aircraft. As further discussed in [19], UAVs are typically used for other kinds of missions, posing different requirements on decision support for fighter pilots and UAV operators.

The generation of options is made more complex in a collaborative environment. The collective best option is not necessarily the combination of the top-ranked options of the individual decision makers. There might be synergies and conflicts that need to be taken into account that are not apparent in the situational space. Liu et al. [3] developed a framework called collaborative option awareness for joint actions (COAction). In their study, the participants were aided with their decision making through visualizing the six best-ranked options among all possible combinations of actions. However, some of the participants were only provided with two separate views of the decision space – one's own and his/her partner's, whereas others were presented with a joint view, indicating the decision scheme applied by the partner. The study showed that collaborative decision making was improved by the joint decision space support, especially when the best option was not amongst the individual top-ranked options [3].

In the study by Liu et al. [3], the participants were allowed to use a chat tool to communicate with each other regarding their options. Such communication is also possible in the fighter aircraft. However, fighter pilots often need to make decisions fast and do not have time for long discussions. Thus, to develop a team option awareness tool, one must first closely analyze the forms of collaboration to prepare the support for rapid decision making with minimum communication and negotiation between the pilots in mind. Moreover, in the study by Liu et al., the participants were collaborating in pairs. In the fighter aircraft domain, pilots are often working in larger teams, something which must be taken into account when generating, evaluating and visualizing the best options.

3 Analysis of Two Situations

In order to analyze how the concept of option awareness can be applied in the fighter aircraft domain, two situations with different characteristics are used. By comparing these situations, we expect to identify challenges applicable to the domain.

3.1 Reconnaissance Scenario

In the reconnaissance scenario, a team with two aircraft should gather information about eight interesting objects. This implies that one of the aircraft needs to fly close to the object and direct its sensors towards it. The objects are located inside enemy territory and the pilots should avoid getting detected and hit by the enemy sensor and weapon systems.

Representing Options. There are several different ways of describing the options in this scenario. At a high level of abstraction, the options could be an allocation of which aircraft that should visit which object, for instance that aircraft A should visit the four western objects and that aircraft B should visit the remaining ones. At a more detailed level, the options describe in which order the objects should be visited and how the pilots should fly between two objects. Figure 1 shows two different routes for each aircraft in the scenario.

Even in this small example, the number of possible options is typically so large that the pilots will not be able to consider all of them. Furthermore, many of these potential options are not suitable since they will not enable the pilots to perform the mission task with a low risk. The decision support system therefore needs a way to generate a manageable amount of suitable options. These options should also be significantly different, so that the pilots do not have to consider many similar options.

Evaluating Options and Estimating Consequences. The way of representing the options influences the way in which they can be evaluated and which consequences that can be predicted. When the options are described as allocating objects to the pilots, the different options can be evaluated based on how many objects the team can visit in total. However, there are also objectives connected with combat survival and flight safety that might have to be considered.

A survivability model for calculating the probability that an aircraft can fly a route unharmed in the presence of enemy sensor and weapon systems was presented in [20]. In order to use that model for predicting the consequences of an option in terms of survivability, the options need to describe the route of the aircraft in relation to the enemy's systems as in Fig. 1. Another important perspective is the fuel consumption, which depends on the aircraft's speed, altitude and acceleration. The option descriptions depicted in Fig. 1 allows for calculating the route length and assuming that it is proportional to the fuel consumption. Even though this is a coarse simplification, it still gives an indication of how two options can be compared in case the fuel consumption is not critical. However, in case the fuel margins are small, a more accurate estimation should be used to avoid that the aircraft run out of fuel.

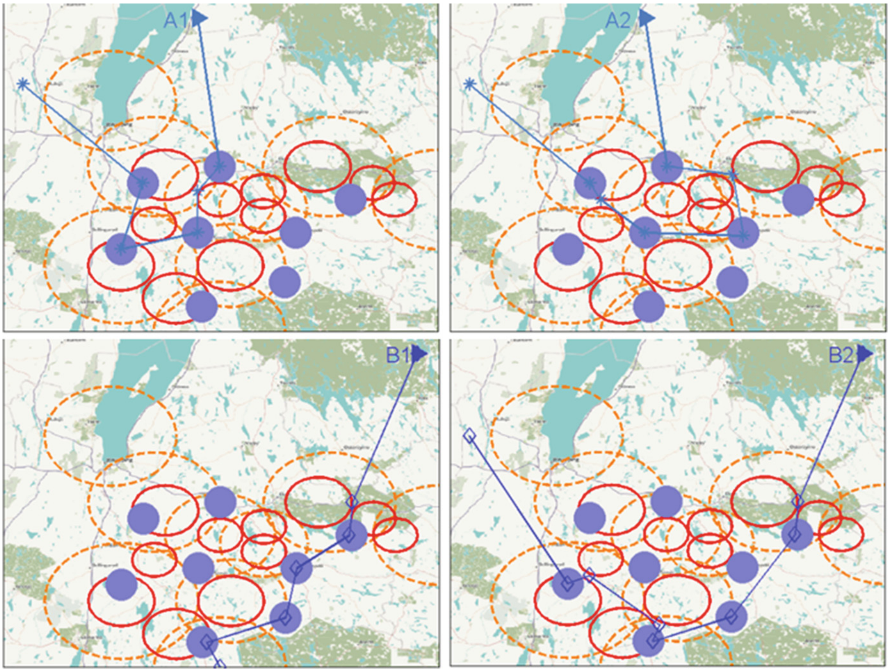

Fig. 1. The maps depict the reconnaissance scenario, where the team should gather information about the eight objects of interest (blue filled circles). The hostile area is protected by enemy sensors (orange dashed circles) and weapon systems (red solid circles). The options are described as routes with waypoints, where the starting point is indicated with a triangle. Pilot A can choose between options A1 and A2 (top) and pilot B can choose either option B1 or B2 (Color figure online).

Consider the scenario above and suppose that pilot A selects option A1 and that pilot B selects option B2. Even though both aircraft visit four objects each, together they only visit seven of the object, since one object is visited by both aircraft. It is therefore not reasonable to evaluate the combinations of options for the team independently. Instead, the evaluation should take into account that both aircraft will visit the same object, for instance by splitting the scores for object both of them visit. The expected mission score for a team with J aircraft and K objects can be estimated as:

$$ESM = \sum\nolimits_k \left(\sum\nolimits_j \left(assigned(j,k) \times surv_j(t_k) \times \frac{score_k}{\sum_j assigned(j,k)} \right) \right).$$

assigned(j, k) is an indication function which equals one if aircraft j passes near object k and zero otherwise. $surv_j(t_k)$ describes the survivability for the aircraft j at the time when it passes object k. $score_k$ is the score for the object k.

Option selection. Table 1 shows the estimated consequences for the four possible combinations of the options in Fig. 1.

Table 1. Evaluation based on mission score, survivability and route length for the combination of the options displayed in Fig. 1.

Options	Expected mission score	Survivability A	Survivability B	Route length
A1 and B1	7.71	76 %	100 %	1966 (1097 + 868)
A1 and B2	6.77	76 %	86 %	2514 (1097 + 1416)
A2 and B1	6.91	80 %	100 %	2084 (1216 + 868)
A2 and B2	7.85	80 %	86 %	2632 (1216 + 1416)

Unsurprisingly, the highest expected mission score is achieved for the combination A1/B1 and A2/B2, since these combinations totally visit all eight interesting objects. However, it is not obvious how to select the best option. The combination with highest survivability is A2/B1, but this option only gets 6.9 in expected mission score, since only seven objects are visited. The combination A1/B1 maximizes the sum of survivability and the combination A2/B2 maximizes the minimum survivability for both aircraft. The route lengths are also displayed for illustration, even though that it should be noted that the comparison is biased since the final point for aircraft B differs. Route length is likely a less important objective than expected mission score and survivability. However, it could be used for selecting between similar options.

The evaluation above is based on the information regarding enemy sensors and weapons that is given in Fig. 1. However, this information might be inadequate or incomplete, since the enemy is moving and hiding its systems. It is therefore wise to constantly re-evaluate the options during flight, when the situation changes. It might be reasonable to accept a risky option during the planning of the mission, but abort the mission during flight in case the enemy is firing against the team. Another opportunity would be to include this uncertainty in the evaluation of the options.

3.2 Air Combat Scenario

The second situation is depicted in Fig. 2 and shows an air combat scenario. The team of white aircraft has detected two black opponents. However, they have also received information from other own troops that there are more opponents in the air. Their mission is to protect the own airspace from the intruders. The team should therefore detect, track and identify all intruders and either persuade them to fly away or shoot them down. However, they also need to be careful and avoid enemy missiles.

This scenario is more dynamic than the previous one, which implies that the options need to be described in a different way. The planning horizon is shorter and the pilots do not have time for deep analyses before making a decision. This situation could be handled as an assignment problem, where each of the white aircraft should be assigned a target in such a way that the probability for shooting down the two black aircraft is maximized. However, the mission objective is to defend the airspace from all intruders and the intelligence information implies that there are at least three other enemy fighters than the two detected ones. It is therefore not suitable to waste valuable

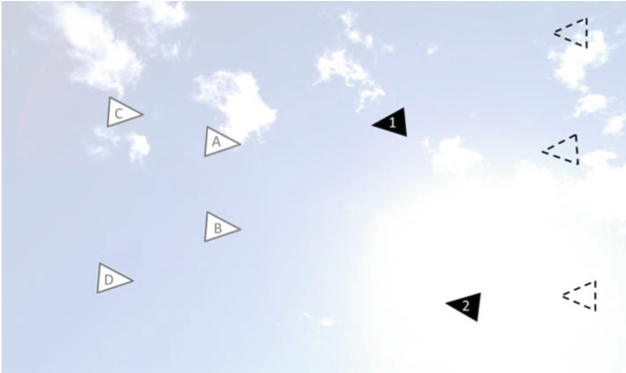

Fig. 2. The figure illustrates a snapshot of an air combat scenario. The white team (left) has detected two black opponents (right). The pilots have received information that there are more opponents in the air, but have not detected them yet (indicated with dashed triangles) (Color figure online).

resources, especially if the probability of hit is low. Furthermore, the present situation might be dangerous and some pilots might need to turn away in order to avoid enemy missiles. Consider the pilot in aircraft A. There are (at least) five relevant options to consider in this case: fire against enemy aircraft 1, approach enemy aircraft 1, fire against enemy aircraft 2, approach enemy aircraft 2 or withdraw. Withdraw does not necessarily mean that the pilot is aborting the mission, but merely that he/she is flying away with the intention to return later on. These options could be evaluated based on resources, opportunity and risk as well as how they affect the overall mission goal.

Resources and Information. The team of aircraft carries resources such as fuel, sensors and different kinds of weapons, which all can be used for improving the outlook of the situation. Even though the pilots cannot directly share the resources, the team members' resources indirectly affect the situation for the individual pilot. For instance, information from the sensors can be distributed within the team and a team member with weapons can threaten or shoot an enemy fighter. When evaluating an option, the pilots might need to be aware of the team's total resources as well as how the resources are distributed.

In the situation depicted in Fig. 2 the pilots have good knowledge of the two detected opponents. However, intelligence information suggests that there are at least three other enemy fighters in the surroundings. If the team has actively used their sensors for searching the airspace, it is likely that the other opponents are further away than the two detected ones. The information situation is likely to improve if the aircraft continue to fly in the same direction towards the enemy fighters. On the other hand, if an aircraft turns away such that the enemy fighters are no longer within the team's sensor field of view, the data quality regarding the enemy aircraft will decrease, unless another aircraft can track them.

Opportunity, Risk and Mission Score. The pilots can decide to fire missiles against the enemy fighters or wait for a more advantageous situation. An important perspective for this decision is the probability of hitting the intended target. This opportunity depends on the geometry between the aircraft and target as well as the capability of the weapon. Furthermore, the probability of hitting the aircraft also depends on the quality of the information regarding the enemy's kinematics.

The risk for a single aircraft is highly connected with the enemy's opportunity to fire a missile that will hit the aircraft. However, the enemy pilots are also assessing their risks and opportunities and might decide to fly to a better position with respect to opportunity or survivability. In this sense, the situation can be pictured as a game where all players are aiming for favorable situations while preventing the opponents to do the same. In fact, one-on-one air combat has been modeled with game theoretic approaches, see [21]. It is plausible that extending these approaches to handle team air combat would be useful for option evaluation in these kinds of situations.

The goal of the mission is to protect the airspace against intruders. Usually, it is not possible to reach the mission goal with a single action, but the pilots need to make many decisions in order to accomplish this. Nevertheless, one important perspective when evaluating an option is whether the option leads towards the mission goal. In the scenario described in Fig. 2, the estimated numbers of undetected, detected and disarmed intruders be used for evaluating the situation with respect to the mission objective.

Option Awareness for Air Combat. The discussion above has identified five relevant options for the pilot in aircraft A and a number of parameters that could be evaluated. Table 2 summarizes the options and shows examples of their anticipated consequences. Instead of evaluating the options in absolute numbers, they are evaluated based on whether they will improve or worsen the situation for most of the parameters. An advantage with this approach is that the models used for anticipating the consequences can be fairly simple. On the other hand, it might be difficult to separate the options. For instance, should pilot A approach target 1 or target 2?

Table 2. - Options for aircraft A together with assessments of how the options would affect the situation.

	Fire against 1	Fire against 2	Approach 1	Approach 2	Withdraw
Information	Same	Same	Increase	Increase	Decrease
Weapons	Decrease	Decrease	Same	Same	Same
Opportunity	75 %	58 %	Increase	Increase	Decrease
Opportunity (team)	B: 31 % C: 27 % D: 9 %	B2: 45 % C: 13 % D: 11 %	N/A	N/A	N/A
Risk (own)	Decrease	Decrease	Increase	Increase	Decrease
Risk (team)	Decrease	Decrease	Same	Same	Increase
Undetected	Same	Same	Same	Same	Increase
Detected	Same	Same	Same	Same	Decrease
Removed	0.75	0.58	0	0	0

4 Discussion

The analysis of the scenarios above has concluded that options can be represented and described at different levels of abstraction. For instance, in the air combat situation, many things can happen in a short period of time. It is therefore feasible to consider short time horizons since it is not possible to accurately predict how the situation will evolve for longer periods of time. The reconnaissance scenario is less dynamic and it is possible to describe options for the entire mission, such as different routes. A challenge for future work could be how to mix options represented with different time horizons. For instance, in the reconnaissance scenario, one pilot might have to deviate from the planned route in order to avoid a newly detected enemy system. In case the deviation is small, the original mission point assignment might still be suitable. However, if the deviation is large, it might be suitable to modify the mission point assignment for the entire team.

The representation influences how the option can be evaluated and which consequences that can be predicted. For instance, a simple allocation of reconnaissance objects to the aircraft can be evaluated based on how many objects the team can visit. Evaluating the risk associated with the different options requires information of how the aircraft should fly in relation to the enemy's systems. An accurate prediction of the fuel consumption requires detailed information regarding aircraft speed and altitude as well as wind information. However, unless the fuel level is low, the importance of fuel information is likely low when evaluating the options and a simple model should be sufficient.

The selection of the options within the team should not be performed independently, since some of the objectives might affect the entire team. In the reconnaissance scenario, the expected score for the entire team was calculated instead of the individual expected score. When deciding whether to shoot or withdraw in the air-to-air combat scenario, the pilots should consider how this decision influences the mission objective, but also the risk for the other team members. Depending on the team tactics, the team might want to divide the risk evenly over the team or let one team member take higher risks in order to increase the chance that the others can return safely to the base.

The scenarios clearly illustrate that even in these limited examples, there are several options to consider and each option can be evaluated in several ways. Furthermore, there is no obvious way of how to select the right option in these multi-criteria decision situations. A great challenge is thus associated with communicating the different options and their probable consequences to the pilots on the limited visual displays of the aircraft. Much training is likely needed, both for enabling the pilots to get accustomed to the option concept and to understand how the option generation model works. Of essential importance is the interaction between the pilot and the model. In order for the pilot to trust and effectively use the model, he/she must also be able to, some degree, understand and influence the reasoning conducted, for example by adjusting the details of the different options. Here, the framework of *visual analytics* can be of great aid, where a close interaction between the data, model, analysis and user is strived for (see for instance [22]).

5 Conclusions and Future Work

This paper has argued that technical support for creating team option awareness would aid fighter pilots fly different kinds of missions. Yet several challenges have been identified through the analysis of two typical situations. The analysis emphasized both similarities and differences between these situations, which need to be handled in order to create support that can aid the pilots in a variety of situations. A great challenge is to choose a representation of how to describe the options in different situations and which consequences that should be predicted. Furthermore, there are typically a large number of potential options and the pilot will not have time to evaluate all of them. The decision support system therefore needs to filter out the relevant ones.

The evaluation of options requires models of how the situation will evolve if a specific option is selected. The accuracy and complexity of these models depend on how the options are described but also on uncertainty regarding the situation as well the importance of the objective. Finally, it has been shown that the options should not only be evaluated regarding the single aircraft but also with respect to the team. This includes both the team's common mission goal, but also how the risk, opportunity, information situation and resources will be affected by an option.

Acknowledgement. This research has been supported by VINNOVA (Swedish Governmental Agency for Innovation Systems) through the National Aviation Engineering Research Program (NFFP-2013-01201), Saab AB and the University of Skövde. We would like to thank Göran Falkman and Anders Dahlbom (University of Skövde), Jens Alfredson and Per-Johan Nordlund (Saab AB) for their valuable feedback.

References

1. Langan-Fox, J., Canty, J.M., Sankey, M.J.: Human-automation teams and adaptable control for future air traffic management. Int. J. Ind. Ergon. **39**, 894–903 (2009)
2. Miberg Skjerve, A.B., Skraaning Jr., G.: The quality of human-automation cooperation in human-system interface for nuclear power plants. Int. J. Hum.-Comput. Stud. **61**, 649–677 (2004)
3. Liu, Y., Moon, S.P., Pfaff, M.S., Drury, J.L., Klein, G.L.: Collaborative Option Awareness for Emergency Response Decision Making. In: Proceedings of the 8th Annual Inter. Conference on Information Systems for Crisis Response and Management (ISCRAM), Lisbon, Portugal (2011)
4. Klein, G.L., Drury, J.L., Pfaff, M.S.: Providing an Option Awareness Basis for Naturalistic Decision Making. Cogn. Technol. **16**, 10–19 (2011)
5. Pfaff, M., Drury, J., Klein, G., More, L., Moon, S.P., Liu, Y.: Weighing decisions: aiding emergency response decision making via option awareness. In: Proceedings of the IEEE International Conference on Technologies for Homeland Security, pp. 251–257 (2010)
6. Pfaff, M.S., Klein, G.L., Drury, J.L., Moon, S.P., Liu, Y., Entezari, S.O.: Supporting Complex Decision Making Through Option Awareness. J. Cogn. Eng. Decis. Making **7**, 155–178 (2013)
7. Atoyan, H., Shahbazian, E.: Analyses of the concept of trust in information fusion and situation assessment. In: Shahbazian, E., Rogova, G., DeWeert, M.J. (eds.) Harbour Protection Through Data Fusion Technologies, pp. 161–170. Springer, Netherlands (2009)

8. Lim, B.Y., Dey, A.K., Avrahami, D.: Why and why not explanations improve the intelligibility of context-aware intelligent systems. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 2119–2128, Boston, MA, USA, (2009)
9. Schulte, A.: Cognitive automation for tactical mission management, concept and prototype evaluation in flight simulator trials. Cogn. Technol. Work **4**, 146–159 (2002)
10. Endsley, M.R.: Theory of situation awareness in dynamic systems. Hum. Factors **37**, 32–64 (1995)
11. Hall, D.L., Hellar, B., McNeese, M.D.: Rethinking the data overload problem: closing the gap between situation assessment and decision making. Presented at the Symposium on Sensor and Data Fusion, Military Sensing and Symposia, McLean, VA, USA (2007)
12. Helldin, T., Erlandsson, T., Niklasson, L., Falkman, G.: Situational adapting system supporting team situation awareness. In: SPIE - Unmanned/Unattended Sensors and Sensor Networks, Tolouse, France (2010)
13. Erlandsson, T., Helldin, T., Niklasson, L., Falkman, G.: Information fusion supporting team situation awareness for future fighting aircraft. In: 13th International Conference on Information Fusion, Edinburgh, UK (2010)
14. Matlock, A., Holsapple, R., Schumacher, C., Hansen, J., Girard, A.: Cooperative defensive surveillance using unmanned aerial vehicles. In: American Control Conference (ACC 2009), pp. 2612–2617 (2009)
15. Acevedo, J.J., Arrue, B.C., Maza, I., Ollero, A.: Distributed approach for coverage and patrolling missions with a team of heterogenous aerial robots under communication constraints. Int. J. Adv. Rob. Syst. **10**, 1–13 (2013)
16. Girard, A.R., Howell, A.S., Hedrick, J.K.: Border patrol and surveillance using multiple unmanned air vehicles. In: 43rd IEEE Conference on Decision and Control, Nassau, pp. 620–625 (2004)
17. Spry, S.C., Girard, A.R., Hedrick, J.K.: Convoy protection using multiple unmanned aerial vehicles: organization and coordination. In: Proceedings of the 2005 American Control Conference, pp. 3524–3529 (2005)
18. Kvarnstrom J., Doherty, P.: Automated planning for collaborative UAV systems. In: 11th International Conference on Control Automation Robotics & Vision (2010)
19. Erlandsson T., Niklasson, L.: A five state survivability model for missions with ground-to-air threats. In: SPIE - The International Society for Optical Engineering Baltimore, Maryland, USA, (2013)
20. Erlandsson, T., Niklasson, L.: Automatic evaluation of air mission routes with respect to combat survival. Inform. Fusion **20**, 88–98 (2014)
21. Virtanen, K., Karelahti, J., Raivio, T.: Modeling air combat by a moving horizon influence diagram game. J. Guidance Control Dyn. **29**, 1080–1091 (2006)
22. Keim, D.A., Mansmann, F., Oelke, D., Ziegler, H.: Visual analytics: combining automated discovery with interactive visualizations. In: Freund, Y., Györfi, L., Turán, G., Zeugmann, T. (eds.) ALT 2008. LNCS (LNAI), vol. 5254, pp. 2–14. Springer, Heidelberg (2008)