

# Understanding Team Effectiveness in a Tactical Air Unit

Ulrika Ohlander<sup>1,2(✉)</sup>, Jens Alfredson<sup>1</sup>, Maria Riveiro<sup>2</sup>,  
and Göran Falkman<sup>2</sup>

<sup>1</sup> Saab Aeronautics, Saab AB, Linköping, Sweden  
{ulrika.ohlander, jens.alfredson}@saabgroup.com

<sup>2</sup> University of Skövde, Skövde, Sweden  
{maria.riveiro, goran.falkman}@his.se

**Abstract.** Effective team work is regarded as a key factor for success in missions performed by fighter aircraft in a Tactical Air Unit (TAU). Many factors contribute to how a team will succeed in their mission. From the existing literature on teamwork, Salas, Sims and Burke [1], suggested five main factors and three supporting mechanisms for effective team work. These were proposed as the “Big Five” of teamwork. This article investigates if the model offered by Salas et al. is applicable to a TAU of fighter aircraft. Semi-structured interviews were carried out with six fighter pilots. The results of these interviews imply that the model has relevance for the teamwork in a TAU. Moreover, this paper discusses implications for the design of future decision-support systems that support team effectiveness.

**Keywords:** Team effectiveness · Fighter aircraft · Tactical air unit

## 1 Introduction

Collaboration in teams is in many operations a necessity in order to achieve the goals of an organization. A team can perform tasks that would be impossible to effectively accomplish with just single entities acting in an uncoordinated fashion. In the military fighter domain, the unit of operation often consists of two to four aircraft flying in a group, called tactical air unit. Modern fighter aircraft are equipped with sensors and data links to collect and distribute data and information. This is achieved by a decision support system (DSS) which fuses, analyzes data and distributes this information within the TAU. Further, the pilots in a TAU need to coordinate their actions and communicate their intentions for a successful mission. Thus, it is important to design the DSS and pilot interfaces for optimal team performance. However, pilots’ means of communication are often restricted to voice radio and data links. Using the radio is sometimes not advisable, or even possible, due to risk of exposure and enemy jamming of frequencies. Hence, the pilots are sometimes left to infer situations and intentions of the other members of the TAU. This limited ability to communicate makes it challenging to achieve good team collaboration within the military fighter domain. Research in a simulated context has demonstrated a positive correlation between teamwork and performance in fighter missions [2]. Furthermore, fighter pilots have been found to regard teamwork as crucial for mission success [3].

The purpose of this paper is to analyze and describe teamwork between fighter aircraft in a TAU. The “Big Five” model for effective teamwork suggested by Salas et al. [1] is analyzed in this context. Further, factors crucial to successful team collaboration in the selected scenario are identified. The results could inform further work on establishing guidelines for the design of DSSs for fighter aircraft and methods to assess team effectiveness in the military fighter domain. Hereby, this could be a first step towards a method that allows developers of fighter aircraft to design and evaluate their product for improved team effectiveness.

## 2 Team Effectiveness and the “Big Five” in Teamwork

This section describes important theories and findings in team research and relates them to the TAU in the fighter domain.

A team can be defined as “a distinguishable set of two or more people who interact dynamically, interdependently, and adaptively toward a common and valued goal/object/mission, who have each been assigned specific roles or functions to perform, and who have a limited life span of membership” [4]. For this paper, we would like to stress the difference between team effectiveness and team performance. Performance is a measure on the outcome of the work; what the team accomplishes. Effectiveness is about how the team acts and interacts during the task. A team can perform well and reach its goals but still not be functioning effectively. Hence, focusing only on the outcome and results of the team will not give us any information about how the team reached the goals.

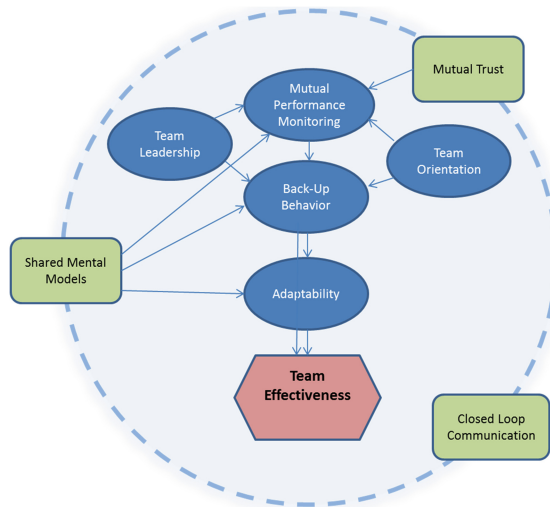
Research on teams is vast and diverse. There is research performed in practically every aspect imaginable, from how to compose teams with respect to different personalities, how to train teams, to how to evaluate how well they perform. The research is also carried out within different domains, such as health care, nuclear plants, military command and control, and air traffic control etc. Salas et al. [1], made an extensive review of the current literature on teamwork and were able to compile more than 138 models that aimed at describing teamwork. They suggested that the combined knowledge about what characterizes a highly effective team could be boiled down to five main factors that can be used to describe effective teamwork, and they suggested naming these the “Big Five” of teamwork. The main factors are leadership, mutual performance monitoring, back-up behavior, adaptability and team orientation. Furthermore, they identified three coordinating mechanisms that support the five main variables; shared mental models, mutual trust and closed-loop communication. The factors and the corresponding behavioral markers that contribute to team effectiveness according to Salas et al. are listed in Table 1 below.

Salas et al. also suggest a model of how the factors and coordinating mechanisms relate to each other which can be seen in Fig. 1 below. The arrows illustrate how they propose that the factors contribute to each other for team effectiveness. The three supporting mechanisms are shown on the border of the circle.

The article about the “Big Five” model has been widely cited in the literature. A database search on Scopus in February 2015 gave 315 citations, and more than half

**Table 1.** The “Big Five” of teamwork, coordinating mechanisms and behavioral markers after Salas et al. [1].

Big five factors and coordinating mechanisms	Behavioral markers
Team leadership	(a) Facilitate team problem solving
	(b) Provide performance expectations and acceptable interaction patterns
	(c) Synchronize and combine individual team member contributions
	(d) Seek and evaluate information that affects team functioning
	(e) Clarify team member roles
	(f) Engage in preparatory meetings and feedback sessions with the team
Mutual performance monitoring	(g) Identifying mistakes and lapses in other team member’s actions
	(h) Providing feedback regarding team members’ actions to facilitate self-correction
Backup behavior	(i) Recognition by potential backup providers that there is a workload distribution problem in their team
	(j) Shifting of work responsibilities to underutilized team members
	(k) Completion of the whole task or parts of tasks by other team members
Adaptability	(l) Identify cues that a change has occurred, assign meaning to that change, and develop a new plan to deal with changes
	(m) Identify opportunities for improvement and innovation for habitual or routine practices
	(n) Remain vigilant to changes in the internal and external environment of the team
Team orientation	(o) Taking into account alternative solutions provided by teammates and appraising that input to determine what is most correct
	(p) Increased task involvement, information sharing, strategizing, and participatory goal setting
Shared mental models	(q) Anticipating and predicting each other’s needs
	(r) Identify changes in the team, task, or teammates and implicitly adjusting strategies as needed
Mutual trust	(s) Information sharing
	(t) Willingness to admit mistakes and accept feedback
Closed-loop communication	(u) Following up with team members to ensure message was received
	(v) Acknowledging that a message was received
	(x) Clarifying with the sender of the message that the message received is the same as the intended message



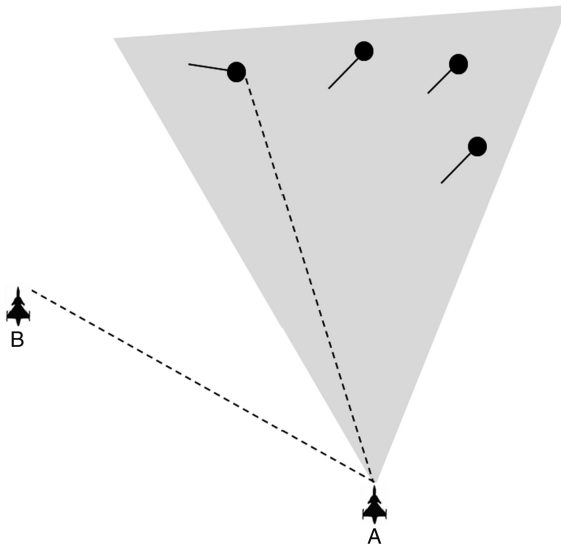
**Fig. 1.** Model of the “Big Five” for team effectiveness, after Salas et al. [1]. The big five factors are represented by ovals while supporting mechanisms are shown as squares. The arrows represent propositions by Salas et al. for how the factors relate to each other.

of these were from 2012 and later. A study, presented in [5], where a sample of 182 participants responded to questions related to their experiences of team work in general, gave support for the model. The model has also been applied and analyzed in view of military teams [6].

### 3 Fighter Domain

A TAU typically consists of two to four aircraft. The aircraft can be identical, which means they are interchangeable in their tasks, but this is not always the case. In some cases, various types of aircraft perform a mission together, and in other cases one of the aircraft is equipped with a special sensor making it the only one who can perform certain tasks. A military team can be classified as an “action team”. The classification is used to describe teams who are highly skilled specialist teams, cooperating in unpredictable circumstances [7]. Other examples of action teams would be response teams (medical, fire fighters), sports teams and air crews (transportation).

In order to illustrate what kind of situations a TAU may encounter, the following example scenario was selected, see Fig. 2. The “B” aircraft is depending on “A” to provide measurements about the enemy aircraft. B is closer to the target and is unable to or does not choose to use the radar actively. Typical questions the pilots in aircraft A and B are asking could be: “Can I trust the information I see on my display?” “Is A aware of B’s intention to engage with the target?”



**Fig. 2.** Example scenario. Cooperative target acquisition

## 4 Method

Semi-structured interviews were performed with six fighter pilots. The interviewed pilots were all male and ranged in age between 34 and 50 years. They had between 1000 and 3000 flight hours of experience on fighter aircraft. They were informed of the purpose of the study and the procedure through textual instructions. They were first interviewed about their experience and views of teamwork in a TAU. This gave a general background on how teamwork is regarded in the fighter domain. Then the interviewees were asked to complete two tasks. First, they were presented to the “Big Five” factors and coordinating mechanisms printed on eight paper slips and were asked to rank them with the most important factor on top. They were asked to relate the ranking to the example scenario. No distinction was made between the “Big Five” factors and the three supporting mechanisms. All eight concepts were handled equally.

For the second task the pilots were given a list of the 23 behavioral markers that Salas et al. gave to describe significant behaviors for the “Big Five” factors and the coordinating mechanisms. The behaviors were listed on a sheet in a randomized order. The pilots were asked to select and mark the five behaviors that they considered to be most significant for effective teamwork relating to the example scenario.

## 5 Results

The results from the ranking and the selected behavioral markers are listed in Table 2 below. For identifying subgroups of factors/subjects, common hierarchical clustering was applied to the interview data.

**Table 2.** Results from the interviews. The behavioral markers that each respondent selected are listed under the factor it belongs to and identified by letters which corresponds to Table 1.

Big Five Factors / Behavioral Markers	P1	P2	P3	P4	P5	P6
Team leadership	1	7	6	5	2	8
	aef	bc	f	ef	ce	f
Mutual performance monitoring	8	2	3	3	6	2
			h			
Back-up behavior	4	6	8	4	8	7
					k	
Adaptability	5	5	2	6	5	4
	n	l	l	l	l	l
Team orientation	3	4	7	8	3	6
			o	o	p	p
Shared mental models	7	1	4	2	7	1
Mutual trust	2	8	1	7	1	5
	s	s	t	s		st
Closed-loop communication	6	3	5	1	4	3
		x				

## 6 Discussion

Since the sample is small it is difficult to draw any conclusions but some remarks and reflections can be made.

“Closed-loop Communication” and “Shared mental models” had the highest rank on average. “Mutual performance monitoring” was selected top three by four pilots. “Back-up behavior” had the lowest rank on average.

Based on the rankings provided, two groups can be seen. The rankings made by P1 and P5 are more similar and the rest show another pattern. P1 and P5 placed “Mutual trust” and “Team leadership” as number 1 and 2. While the others ranked them in the lower end. This might depend on the perception of these two factors. Either they are regarded as fundamental and therefore put first, or they can be regarded as a prerequisite for even going in to the situation with the team.

Leadership turned out to be the factor that collected the most behavioral markers but it also had the most alternatives. When corrected for the amount of alternatives, “Mutual trust” gained most scores and it was ranked 1 or 2 by three pilots. “Team orientation” scored number two together with “Adaptability”. “Team leadership” was number four, very close behind.

One behavior marker stood out and was selected by five of six pilots. It was “Identify cues that a change has occurred, assign meaning to that change, and develop a new plan to deal with changes” (1), and it belongs to the factor “Adaptability”.

Two behavior markers were selected by four of six pilots. “Information sharing”, (mutual trust), and “Engage in preparatory meetings and feedback sessions with the team”, (leadership).

It is interesting to notice how the factors and behavioral markers did not seem to follow the same pattern. The factor “Team leadership” was on average ranked low but it collected many behavioral markers, while “Engage in preparatory meetings and feedback sessions with the team” was the most selected. The factor “Adaptability” was low in rank but the behavioral marker “Identify cues that a change has occurred, assign meaning to that change, and develop a new plan to deal with changes” was the most selected behavioral marker of all (5 of 6). “Shared mental models” and “Closed-loop communication” were the two highest in rank but scored only one behavior marker between the two of them.

A dual perspective can be taken when analyzing the teamwork for a TAU. First there is the long term “preparation” view which includes training, leadership, preparations before mission and evaluation afterwards. Then there is the short term “execution” view which is during the actual mission. “Team orientation” and “Mutual trust” can mainly be regarded as being developed during the long term perspective. Team Leadership is a cornerstone which belongs both to the long as well as the short term perspective. Leadership needs to be present at all times in a team and the foundation for it is laid between missions. During the execution the leadership needs to be flexible since the development of the scenario is unpredictable. “Mutual performance monitoring”, “Shared mental models” and “Close-loop communication” were identified here as important factors during the execution of the mission.

Team effectiveness can be improved by addressing factors from both these perspectives, identifying the long term factors as well as the factors that have impact during the mission. This dual view can be compared to the “sharp end/blunt end” model [8], that describes how errors can be introduced at different levels of an organization. The “blunt end” refers to the factors that are further away in space and time such as management, strategies etc., and the “sharp end” refers to the executing level, “here and now”.

## 7 Conclusions and Future Work

The general impression from the interviews is that the proposed “Big Five” factors and supporting mechanisms were all regarded as relevant and important descriptions for successful teamwork in a TAU. When asked, all interviewees responded that the factors were all important and no one could think of a factor that was missing. The “Big Five”-model is an interesting foundation and helps in the attempt to understand team effectiveness in a TAU. Future work could include to investigate in more detail how each factor and behavior marker manifest themselves and what they denote in this context. It can be noted from the results that the meaning users put into the different factors and behaviors needs to be further clarified for the context. The “Big Five” is a general

model and for it to be useful in a specific context the terms and definitions needs to be specified in more detail.

The aim of this study was to investigate how applicable this model is to a TAU in the fighter domain. The intended outcome was to identify which factors and coordinating mechanisms were considered most important by fighter pilots in the given scenario. With this in mind, future work could be to identify whether the identified important factors and behaviors for a successful mission can be better supported by technology. This could very well benefit further activities towards a system that better supports team effectiveness.

**Acknowledgements.** This research was funded by NFFP (National Aviation Research Programme, NFFP6-2013-01201), which is founded by VINNOVA (Swedish Governmental Agency for Innovation Systems), the Swedish Armed Forces and the Swedish Defence Material Administration. The authors also like to thank Saab AB and the University of Skövde for supporting the project.

## References

1. Salas, E., Sims, D., Burke, S.: Is there a “Big Five” in Teamwork? *Small Group Res.* **36**, 555–559 (2005)
2. Castor, M.: The use of structural equation modelling to describe the effect of operator functional state on air-to-air engagement outcomes. Doctoral thesis, Linköping University, Linköping, Sweden (2009)
3. Helldin, T., Erlandsson, T., Niklasson, L., Falkman, G.: Situational adapting system supporting team situation awareness. In: *SPIE-Unmanned/Unattended Sensors and Sensor Networks*. Toulouse, France (2010)
4. Salas, E., Dickinson, T.L., Converse, S.A., Tannenbaum, S.I.: Toward an understanding of team performance and training. In: Swezey, R.W., Salas, E. (eds.) *Teams: Their Training and Performance*, pp. 3–29. Ablex, Norwood (1992)
5. Moen van Rosmalen, T.: The development of a questionnaire on the subjective experience of teamwork, based on Sala, Sims and Burke’s “the big five of teamwork” and Hackman’s understanding of team effectiveness. Master thesis, The Norwegian University of Science and Technology, Trondheim, Norway (2012)
6. Duel, J.: *Teamwork in Action: Military Teams Preparing for, and Conducting Peace Support Operations*. Koninklijke De Swart, Den Haag (2010)
7. Sundstrom, E., De Meuse, K.P., Futrell, D.: Work teams: Applications and effectiveness. *Am. Psychol.* **45**, 120–133 (1990)
8. Reason, J.: *Human Error*. Cambridge University Press, Cambridge (1990)