Do aircrews trained and working within a same organization develop similar adaptive strategies to cope with complex situations ?

Bourgeon, L.[1], Valot, C. [1], and Navarro, C.[2]

[1] Institut de Médecine Aérospatiale du Service de Santé des Armées (IMASSA),
BP 73 91223 Brétigny-sur-Orge, France
lbourgeon@imassa.fr
cvalot@imassa.fr
[2] Université Toulouse le Mirail
Laboratoire Travail et Cognition
5 allées Antonio Machado
31058 Toulouse cedex 9
navarro@univ-tlse2.fr

Abstract. Resilient behaviour is implicitly expected within a military structure. In this context we are looking at the best trade-off between safety and operational performance. Training, the drawing up of specific rules and strategies, and the homogeneity of practices, reinforce the ability of the structure to develop resilient responses to the exposure to danger. Those exposed are working in this framework. It is interesting to consider the ways in which their actions comply with this context or the ways in which they differ from it. In this study, 10 crews, selected at random from within an operational air unit, were confronted, in a simulator, with aeronautical events of differing degrees of complexity. The observations concern the diversity of the strategies developed, taking into account the homogeneity of the organisational context. The results show great disparity in the responses to the difficulties encountered and in the different placements of the interaction between performance and safety. The role of emotional data such as confidence in one's abilities, is examined during the same flights. This role is not negligible, because it does not fit with the responses of a resilient nature expected in a small group.

1. INTRODUCTION

A number of works on resilience concentrate on the organisational dimension of resilience. The whole organisation is obviously involved when a major failure occurs and it is observed that cultural, hierarchical, structural, technical and human facts express the inability of this organisation to show itself to be resilient.

At the same time, this organisation manifests itself through the people who compose it. Their knowledge, their strategies and their interpersonal interactions combine to produce a network of capabilities. The organisation, via selection, training, and career devices, influences the technical dimension of the personnel so that they show productive and organisational capabilities, and if necessary develop an “in house” spirit which shows their attachment to the organisation. The dimensions inherent to resilience are no doubt of another nature. We are not in the explicit technical dimension of capability, but in the dimension which, for the last decade, the aeronautical industry has qualified as “non technical skills”.

The share of pertinent non technical skills required so that the behaviour of personnel produces resilience does not derive solely from spontaneous individual capabilities. There may be sensitisation, training, and of course a complex reflection process by the specific sections of the organisation in order to produce that which Woods (2006) describes as the downward influence of the organisation, which will facilitate or complicate the activity of the basic personnel. At the same time, this personnel has an upward influence, which may transform the very aims of the organisation.

A more local and ecological approach should then be developed in order to understand how the personnel in an organisation produce resilient behaviour. In fact, individual behaviour is oriented by training, strategic orientation, the recommendations and the culture of the organisation; but it is also the result of the traits inherent to individuals and to small groups. Cognitive activities like diagnosis, decision and coordination are obviously rationalising activities, but they are also subject to emotional influences: self-confidence, self esteem, group dynamics, the metacognition approach to the solving of a problem.

There would seem to be a certain difficulty, in that resilience, as an optimum of the management of the tensions with which the organisation is faced, founders on identifiable human traits, dealt with by training, but fragile and unstable in situations of high individual and collective tension.

We are therefore in the perspective of the observation of personnel in an organisation (a military organisation to be specific,) which selects, trains and exposes its personnel to complex and potentially dangerous situations, expecting them to overcome them with efficiency and implicitly, resilience.

Are these gains achieved, do the emotional dimensions play a disturbing role or are they well managed by training, technical tools and the hierarchical and functional organisation of the group in the situation ?

2 IMPLICIT OR EXPLICIT RESILIENCE

2.1 An example of implicit evaluation of resilience

During the first conflict in Bosnia, in 1995, a French aircraft was shot down by the Serbian air defence. The two crew members, injured during the ejection, were captured and kept in captivity. For more than 100 days, they were frequently moved, brutally interrogated, subjected to simulated execution, separated, undernourished, before being freed and returned to their national territory. The context of the flight, the circumstances of the captivity and the behaviour of this crew were studied in depth by the French Air Force Staff. One question among others provided a subject of discussion: should flight crew receive specific captivity training? In addition to general geopolitical information, is it necessary to sensitise, and even prepare crews for severe interrogation and hard psychological treatment situations, in order to support them in such circumstances?

Considering the facts, the conclusions were that the training undergone by this crew had given them sufficient capabilities since, as they had been "selected" at random and exposed to the captivity situation, they had been able to overcome these very difficult circumstances efficiently. The two members of this crew returned to their operational units. It was not therefore considered necessary to develop specific additional training for situations which other nations had characterised as potentially traumatising.

Leaving aside any analysis in terms of resilience, the French Air Force Staff then considered that their personnel had the effective capabilities to enable them to encounter situations of rupture, which, although predictable in principle had not been dealt with by any specific preparation. No other captivity situation followed this incident, enabling this vision of capabilities and implicit resilience to be questioned or confirmed.

What we find here, is the tension, inherent to resilience, between the permanent dimensions of an organisation and its ability to adapt to highly disturbing situations. Military organisations show several interesting characteristics with regard to this subject. They themselves find the models for personnel capabilities (personnel training, definition of their equipment, drawing up of rules for use, definition of mission profiles, structuring of a strong hierarchical framework…). This produces rigidity, standardisation, and indefinite repetition, in order to be able to react quickly and in a structured way. They also construct themselves in order to be able to face major disturbances in the operations which they carry out. It is then a question of transforming, reorganising, and modifying the rigidity and the standardisation in order to make them in to factors of resilience. Flin notes this characteristic (chp 14 p 22) of military systems as "training their commanders to be resilient" i.e. to develop the diagnostic, decision-making and assertiveness skills". In fact, a number of attempts have been made in civil and military aeronautics to reinforce these capabilities; they are to be found under the generic term of CRM (cockpit resource management). The managerial resilience, thus developed, is defined by Flin as the ability to deal with conflict safety and performance goals.

However strange it may be, the context of military operations is interesting as it amplifies and reinforces the dynamics of effects between individuals and organisations analysed for resilience. Leadership undoubtedly occupies a central place, but its exercise remains an individual dimension, the procedures and rules are common but their use is variable. As a result, the trade-off between performance, risk, mission and safety is variable. The importance of self-confidence, confidence in the organisation and in the leader cannot be neglected in this approach.

2.3 Confidence

Confidence in one's capabilities or in those of other members of the group is a factor, whose impact on individual or group performance has been demonstrated by a number of studies. More particularly, self-efficacy beliefs which are « people's judgments of their capabilities to organize and execute courses of actions required to attain designated types of performances » (Bandura, 86), have often been demonstrated as a

positive performance factor. In addition, self-efficacy belief (SEB) also has an impact on the nature of the interactions between the members of the group since it acts on the modes of cooperation between the members of a group. Now, cooperation between crew members, exchanges of information and aids to problem solving are important elements of resilience, since they make the crew more flexible to changes in situations (Woods, 2003). However, contradictory results have been observed concerning the link between self-efficacy and requests for aid. Certain work has shown a positive link, in which learners with low SEB require less aid than high SEB learners, as this request for aid would seem to continue to give them the impression of failure (for example Ryan, Gheen and Mifgley, 1998). In a study concerning the activity of pilots (Prinzel, 2003), the results showed that those with a high individual SEB have less use of automated aids and preferred to carry out the task themselves when the workload was high. The author explains the results as a response to self evaluation of capabilities: when a pilot has the impression of high efficacy, he does not feel it necessary to use aids, whereas the pilot who has the impression of low efficacy looks for external aids to accomplish the task. Similar results are found in studies on experts in which such experts, having high confidence in their capabilities, exercise less control on the actions than novices (Amalberti,1996). Also it seems that the individual characteristics of self efficacy belief could have an impact on the resilience of the group, in spite of the support efforts conceived by organisations.

3 METHODOLGY

Participants

The sample was composed of 30 flight crew (29 men and 1 woman) from the French Air Force selected at random, but in accordance with crew composition norms. Ten 3-member crews were then constituted, composed of a captain, a first officer and a flight engineer. The participation in the study was on a voluntary basis with complete anonymity of the personnel.

Materiel

The 10 crews were observed during *Mission Oriented Simulation Training* (MOST) in a transport aircraft simulator (*Transall C 160*), the military equivalent of *Line Oriented Flight Training* (LOFT) in civil aviation. The observations were made at the Evreux air base in France.

Scenario

A scenario was designed so as to confront the 10 crews with the same incidents whose management differed in terms of management aid by the organisation:

1) *Failure with associated checklist :* failure of defrosting equipment (cycler).

The management of this incident is simple since it is anticipated by the organisation by means of the application of an associated checklist.

2) *Failure without associated checklist :* loss of the *Command Instrument Rating* (CIR). This incident is more complex since it involves two simultaneous failures: the loss of radio communications and navigation facilities. No checklist is associated with this incident. Yet, once the nature of the incidents has been identified, a single action is required to re-establish the navigation facilities: i.e.; the "reset CIR". After this action, the navigation system is recovered but radio communications remain down until the end of the flight.

3) *Failure with checklist in an uncertain context:* Engine superheat over the Alps, 2 minutes after the point of no return, without weather information. The engine superheat is followed by emergency procedures and a rerouting decision must be taken. The uncertain context is created first by the trigger delay (two minutes after the point of no return), second by the radio communications loss that prevents them of knowing the weather conditions and last by the knowledge of the bad weather condition on the diverting field gathered at take-off. Additionally, they are flying above mountains. Hence, this decision making is highly complex and under time constraints.

Data gathered

The self efficacy belief of the operators was measured by the General Self-efficacy Scale whose rating was adapted by each person to their activity. For each status, the five operators with the highest level were grouped as high self efficacy and the five with the lowest level were grouped as low self efficacy.

The level of experience of the C160 pilot was measured by the number of flying hours on C 160 aircraft. The two classes were composed of the five persons with the most flying hours (high experience) and those with the least flying hours (low experience).

All verbal messages sent during management of the three incidents where were re-transcribed. The messages were encoded in accordance with certain resilience criteria (Woods, 2003): anticipation, flexibility, reflected by messages concerning updating of the situation and finally the exchange of information. Then the percentage of messages concerning each of these indicators was calculated.

Finally, an analysis concerning the content of the communications and actions was carried out in order to understand in more detail the influence of the organisation and of the individual factors on the adaptation strategies of the crews to cope with complex situations.

4 RESULTS

1) Adaptation strategies depending on the type of failure

The figure 1 below shows the proportions of messages concerning anticipation of changes in the situation, updating of the situation and finally the exchange of information (the total exceeds 1% of information exchange redundancy).

The failure with check list is the one in which verbal announcements represent a resilient strategy. Information exchanges, situation and dates and anticipation are important in this. On the contrary, failure without check list produces less updating, less anticipation and less exchange of information. For the crew this is a non recorded failure requiring more adaptation behaviour but less obvious with respect to verbal exchanges.

The third complex failure, with check list, but with uncertainty, also shows a paradox. Anticipation of the consequences of decision is very reduced.

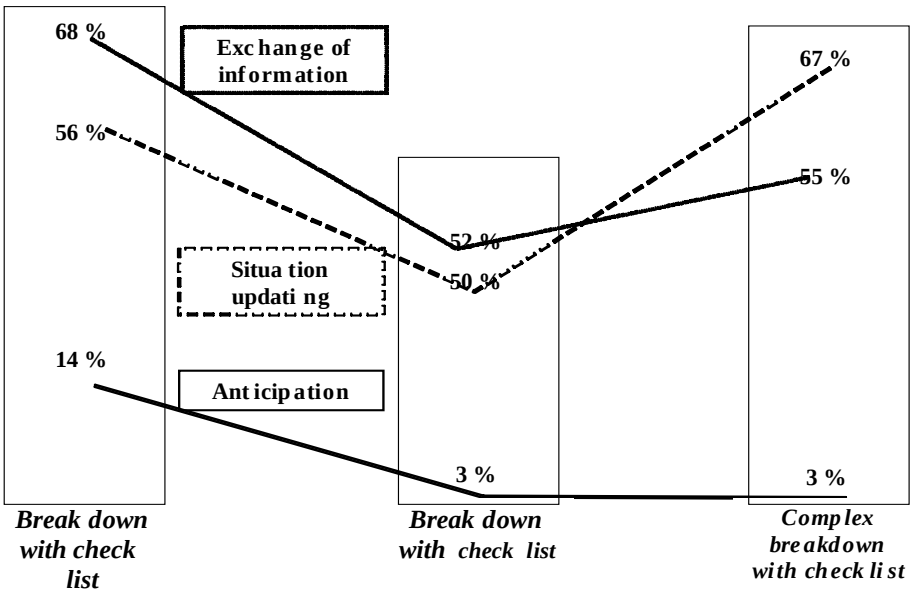

Figure 1: Proportion of messages according to function and break down

2) Effect of self efficacy belief (SEB) of the members of the crew and specific strategies

A detailed analysis of the communications shows that when incident management is dealt with by a procedure by the organisation it involves specific processes.

In this way, the management of a simple failure with check list involves anticipation for all crews of the possible loss of the second defrosting device and therefore of the search for non defrosting conditions. On the contrary, in management of failure in an uncertain context which involves more autonomous decision-making, the degree of anticipation shown is variable. In this way, crews characterised by high familiarity between crew members and a captain with a high level of experience and self efficacy rapidly take the decision to change course after engine superheat, with no anticipation of the consequences of the change of course. However, one crew considered that the weather conditions could be unfavourable in Turin and calculated that it would have enough fuel to fly to another landing ground. This crew was characterised by low familiarity between crew numbers and by a captain with a high level of experience and self efficacy.

An essential characteristic of resilience is the ability to adapt in spite of the pressure linked to mission success. Now, our observations show that during management of the loss of CIR (failure without check list) three crews chose to change course rather than continuing with the flight plan as the procedure for radio failure required. These crews considered that it was safer to return to France rather than to overfly the Alps without weather information in the direction of a foreign country where repairs would take longer. These crews and therefore preferred to “sacrifice” the success of their mission and to change course. These were crews in which the captain had a low level of experience.

Communications breakdowns were also observed during the three types of incidents. These were breakdowns between the captain and the flight engineer. In this case, during failure with check list (cycler failure) the flight engineer announced the alarm 3 times without the captain asking him to apply the check list. This flight engineer therefore carried out the check list on his own initiative. During a failure with check list (loss of radio) another flight engineer dealt with the failure completely without communicating with the two pilots, as he did not wish to disturb them. Finally, in another example was observed during failure with check list and with uncertainty (engine failure), in which a third flight engineer applied a long check list in silence without being ordered to do so, again, in order to not disturb the two pilots.

Finally, a detailed analysis of the communications also showed that during management of failure without associated check list, four crews managed the incident while trying to apply and find the solution in other check lists. Three of these crews were characterised by low familiarity between their members.

5 CONCLUSION

The initial expectation of homogeneous responses to variable events resulting from a high level of structuring was far from satisfied. Of course, when a failure was known and procedure existed it was applied without fault. This is simple adaptive behaviour in and identified context for which the defence mechanisms of the organisation are already in place. Overall, anticipation was the poor relation in the air crew strategies observed. Their depth of analysis was modest, whereas the volume of data exchanged and situation updating was very considerable. One could be tempted to see, in this contrast, the effects of CRM type training, which insists on exchanges, and on the pooling of data in a concept of participatory leadership.

Strangely, failure without check list produced less exchanges and updating than failure with check list. The crew is nevertheless confronted with a more awkward situation, as the failure in question results in a radio failure which considerably reduces the operational capabilities of the aircraft and its crew.

It is no doubt this situation which reveals the most interesting behaviour in terms of resilience. We have already pointed out that three crews decided to change course and return once radio failure had occurred. In this, they contravened the regulations which state that they should maintain their course and announce that they are in an emergency situation so that air traffic control can process the specific trajectory of the aircraft in

question. The post observation interviews showed that these three crews considered that the operational capacities of the aircraft were considerably reduced by the absence of radio contact which did not allow them to update their weather data. In their opinion, continuation of the flight to a foreign landing ground clearly complicated the implementation of the repairs required to continue the mission towards its destination. This decision was made by crews with young captains.

It is not very surprising that the more experienced crews, whose members were more familiar with each other, decided on more risky orientations, with less anticipation. This is one of the known effects of expertise and of small groups. The difficulty arises in that these strategies are more suited to positions in which resilience may be limited and anticipation delayed. In these cases the sudden occurrence of an event decreases the safety margins and makes the event very difficult to manage.

The local approach and the ecological contexts chosen clearly illustrate the concrete implementation of a whole organisation oriented towards safety and performance of technical and human resources. Although the mesh of roles, training, and procedures would seem to be tight, it must be said that it leaves much room for interpretation. Even if a good level of resilience is expected from a military organisation, there is no doubt a case for tightening the mesh in order to improve it. The emotional dimensions (confidence, affective leadership linked to experience and aura) certainly have an important role to play in this orientation towards a resilient attitude, provided that these emotions can be channelled into a good trade-off between safety and performance rather than towards the gratification of pure performance.

REFERENCES

Amalberti, R. (1996). The paradoxes of almost totally safe transportation systems. *Safety Science*, *37*, 109-126.

Bandura, A. (1986). *Social foundations of thought and action: a social cognitive theory*. Englewood Cliffs, N.J. : Prentice Hall.

Flin, R. (2006). Erosion of managerial resilience: from Vasa to NASA. *In* Resilience engineering; Hollnagel, E., Woods, D., Leveson, N. (eds). Ahsgate. Aldershot.

Ryan, A., Gheen, M.H., & Mifgley, C. (1998). Why do student avoid asking for help? An examination of the interplay among student' academic efficacy, teachers' social-emotional role and the classroom structure. *Journal of Educational Psychology*, 90, 528-535.

Woods, D. (2003). Creating foresight: how resilience engineering can transform NASA's approach to risky decision making. Testimony on the future of NASA for Committee on Commerce, Science and Transportation, john McCain, Chair, October 29, 2003. www., accessed on 10-04-05

Woods, D. (2006). Essential characteristics or resilience. *In* Resilience engineering; Hollnagel, E., Woods, D., Leveson, N. (eds). Ahsgate. Aldershot.