Assessing Behaviour towards Organizational Resilience in Aviation

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Abstract. Traditionally safety management focuses on things that can go wrong (losses, harm, incidents and accidents) rather than on the positive side. Since Air Traffic Management (ATM) already is an ultra-safe industry with very high safety standards new safety management approaches may be necessary to keep standards high in light of future challenges such as managing increased automation and conflicting goals (capacity, cost, efficiency, environment, predictability and safety). This paper reports on the development and initial validation of an Inventory to assess Behaviour towards Organisational Resilience in Aviation (I-BORA) across three operational groups (N=282) within the aviation industry linked to a list of observable day-to-day behaviours on the job. Four dimensions underlying behaviour towards organizational resilience could be confirmed referring to *Goal directed/ proactive solutions*, *Flexibility*, *Improvisation* and *Availability of Resources*. Draft behaviours towards organisational resilience are presented in preparation for a validation in the simulator. Results are discussed with reference to current research and best practices promoting the resilience engineering perspective for management and staff to overcome system vulnerabilities for competitive advantage.

1 INTRODUCTION

Today aviation staff are required to adjust to rapidly changing processes and highly automated systems and juggle conflicting goals to ensure ever safe, efficient and environmentally friendly operations. Organisations within the aviation industry therefore have adopted a new approach to safety management which is widely known as "resilience engineering" in order to support their staff to cope with these new requirements. The concept of resilience was originally introduced in early childhood psychology referring to an individual's tendency to cope with stress and adversity (Mallak, 1998). Hopkins (2013) argues that the banner of resilience engineering is based on the theory of high reliability organisations (HRO) developed in the early 1980s, where commitment to resilience is one of five characteristics to manage the unexpected. In fact James Reason (2001) cleared the way for the resilience engineering perspective by recognising that it is the human variability, being able to adjust and improvise, that protects the aviation system in a dynamic uncertain world. Shortly after Sheffi (2005) presented the resilient enterprise demonstrating how organisations overcome vulnerability for competitive advantage. Since then the concept of business resilience and continuity has gained significant popularity.

Hollnagel (2006:16) defined resilience "as the ability of a system or an organisation to react and recover from disturbances at an early stage with minimal effect on dynamic stability". Woods (2006) added to this definition four important properties of resilient systems highlighting buffering capacity (size/kind of disruption absorbed by the system without major breakdown), flexibility (ability to restructure in response to changes), margin (how closely a system operates relative to a performance boundary) and tolerance (how a system behaves near a boundary). Woltjer et al. (2013) recently suggested adding values such as "actual operational practices, procedures and techniques", "goal trade-offs" and "human performance" in support of the Single European Sky Research Programme (SESAR). The European Organisation of the Safety of Air Navigation (EUROCONTROL, 2013) considers organisational resilience as a proactive approach to safety management focused on anticipating problems, accepting a wide range of variability, adapting to unstable and surprising environments and designing error-tolerant human/technical systems. By focusing on the things that go right (proactive), rather than the things that go wrong (reactive) resilience engineering takes a position, which fundamentally differs from traditional safety management approaches (Hollnagel, 2011).

1.1 Assessing resilience on organisational level

Hollnagel (2010:4) argued that "it is not possible to represent resilience by a single or simple measurement" and therefore proposed the Resilience Assessment Grid (RAG) assessing four cornerstones of a resilient organisation as potential solution. RAG looks at "the ability to respond to events, to monitor on-going developments, to anticipate future threats and opportunities, and to learn from past failures and successes alike. The engineering of resilience compromises the ways in which these four capabilities can be established and managed." (Hollnagel, 2011: Prologue). Completing RAG requires detailed knowledge on how an organisation operates and implicates that questions are tailored to match the characteristics of an organisation producing a relative rating of the resilience in an organisation. RAG offers a conceptual and methodological basis for engineering resilience on an organisational level. However, it does not provide any guidance on how this goal can be achieved on an individual or team level.

1.2 Assessing resilience on individual level

Human operators are at the sharp end of highly reliable systems ensuring safe operations even when systems fail. Mallak (1998) was one of the first to develop an instrument to assess resilient behaviour in the organizational context of the healthcare industry. He validated his resilience scales (compare Table 1) on a sample of 128 nursing executives producing acceptable values for internal consistency[1]. Sommers (2009) picked up on Mallak's scales to develop the Organizational Resilience Potential Scale (Table 1) tested on 96 public works directors. New developments (Kolodej, Reiter & Kallus, 2012:1) are motivated by the fact that resilient behaviour gets more and more important as a key qualification in the working life. The inventory of resilient behaviour at the place of work was constructed based on a sample of 132 working persons of no specific occupational group suggesting 12 underlying components. Overlapping components with previous research (Mallak, 1998 and Sommers, 2009) are listed in table 1 and form the base for the development of a tool to assess behaviour towards organisational resilience applicable to the aviation industry.

Table 1. Comparison of overlapping components underlying organizational resilience

#	Resilience Scales (Mallak, 1998)	Organisational Resilience Potential Scale (Sommers, 2009)	Inventory of resilient behaviour at the place of work (Kolodej et al., 2012)
1	Goal-directed solution seeking	Goal-directed solution seeking	Goal-directed solution seeking
2	Avoidance	Risk Avoidance	Avoidance/Scepticism
3	Critical Understanding	Critical Situation Understanding	
4	Role dependence	Ability to fill multiple roles	Improvisation, Flexibility
5	Source reliance	Reliance on information resources	Trust/Reliance on information resources
6	Resource Access	Availability of information resources	Resources

1.3 Assessing resilience on team level

Van der Klej, Molenaar and Schraagen (2011:2158) were the first looking at making teams more resilient by studying the effects of shared leadership behaviours on 105 students working on a naval demand and control scenario. They defined team resilience as "the ability of teams to respond to sudden, unanticipated demands for performance quickly and with minimum decrement of performance" and managed to design and test a training intervention to make teams more resilient.

[1]Cronbach's α(alpha) is a statistical coefficient of internal consistency, commonly used by psychologists as an estimate of the reliability of a psychometric test for a sample of examinees. Tabachnik & Fidel (2007) suggest a Cronbach's Alpha of .70 as acceptable level of internal constistency.

1.4 Training for organisational resilience

Basic unit and on the job training programmes in aviation traditionally aimed at building up skills and competencies for the operation of an aircraft or air traffic management system (Dahlström, Dekker, Nählinder, 2006). Although human factors and non-technical skills are long known to be one of the major contributing factors to aviation accidents and incidents, training to that respect still remains low level. Dekker and Hollnagel (2007:4) highlighted that "operational life contains situations whose subtle and infinite variations will mismatch the exact circumstances of training. It may contain surprises, situations that fall outside the textbook. Practitioners must be able to apply skills and knowledge acquired through training, to situations that even the trainer was unable to foresee." Knowing that resilience engineering expects organisations and their staff to bounce back from the unexpected quickly and resume normal operations, the right training approach seems to be even more relevant. Resilience requires management and front line staff to think outside the box and take an organisation or system way beyond the intended design. A recent aviation accidents and incidents review resulted in a rate of 4.2 accidents per million departures in Europe (ICAO, 2013) classifying aviation as ultra-safe industry. Hence, it is striking that stories of human heroes such as Captain Chesley Sullenberger who saved 150 passengers and 5 crew members on US Air Flight 1549 in 2009 by ditching an airbus A320 in the Hudson River are comparably rare. Media speculate that Captain Sullenberger was just lucky, while ambassadors of the resilient engineering perspective believe in remarkable skills to adjust to and compensate for the unexpected (Pariès, 2011). This paper is inspired by this new safety view focusing on human behaviours that make things go right, rather than the negative side.

1.4 Main research question

This paper reports on the development and initial validation of an Inventory to assess Behaviour towards Organisational Resilience in Aviation (I-BORA) across three operational groups within the aviation industry linked to a list of observable day-to-day behaviours on the job.

2 METHOD

This study is part of two year project looking at safety culture maturity, organisational resilience and proactive safety behaviour in aviation performed at the Austrian Air Navigation Service Provider in collaboration with the University of Graz to be completed by 2014.

The method consisted of the development and application of a questionnaire, execution of safety-related reconstruction interviews and behaviour observations (Kallus, Barbarino & van Damme, 1998) during live operations. Interview and observational data are still under analysis, so this paper focuses on presenting results from the initial validation exercise based on questionnaire data with an outlook referring to behavioural data.

2.1 Sample and procedure

The sample consisted of a total of 282 male and female operational staff spread across three different occupational groups (50,71% (n=143) licenced en-route and terminal ATCOs, 30,5% (n=86) air traffic safety electronics personnel (ATSEPs) as well as 16% (n=45) meteorologists, 2,8% (n=8) did not provide their occupational group) and eight different sites within Austria. For data anonymity reasons participants were not asked to provide exact age or gender. The minority of participants (9,4%) were under 25 years old. 33,3% of the participants were in the 26-35 years age-group, 31,1% in the 36-45 years group and 26,2% were above 45 years old. 15% did not select any age group. The majority of respondents (35,5%) had at least 15 years of experience within the organization. 12.1% also had a managerial role, 22.3% were supervisors and 40,3% trainers/instructors. Participation was voluntary during scheduled working hours and participants did not receive any other incentives.

2.2 Measures and Analysis

The Inventory to assess Behaviour towards Organisational Resilience in Aviation (I-BORA) is based on selected questions from the German Inventory of resilient behaviour at the place of work (Kolodej, Reiter, Kallus, 2012). I-BORA consists of 20 statements (translated into English language) regarding behaviour towards organisational resilience related to the past seven days and nights to be answered on a 7-point frequency scale from 0 (never) to 6 (always). For example: "I was able to cope with an unexpected situation without the help of managers." Based on empirical literature (table 1) the 20 statements were originally grouped to relate to four common resilience dimensions such as goal oriented solution-seeking, avoidance/scepticism, information resources and improvisation/flexibility. Data were transformed considering inverted answer formats and underwent principal component analysis (PCA) with Kaiser's criterion and Varimax rotation as well as reliability analysis using SPSS (Statistical Package for Social Sciences) Version 17.0. Missing values were excluded listwise (complete case analysis).

3 RESULTS

From the principal component analysis six factors could be extracted. The associated scree plot indicated a main breaking point after the third component, suggesting a three factor solution accounting for 42,16% of variance. A similar result was achieved when looking at the MET subsample (n=45) resulting in a three factor solution accounting for 53,27% of variance (Heese & Kallus, 2012). Table 2 shows factors loadings in the rotated component matrix.

Table 2. Rotated component matrix (N=282) for 20 questions of the I-BORA

	1	2	3	4	5	6
(1) ... I was able to cope with an unexpected situation without the help of managers.				.711		
(2) … I was able to fill in for a colleague temporarily.				.788		
(3) … I exchanged ideas regarding improvements with my colleagues.	.692					
(4) … I tried to find alternative solutions for a problem.	.784					
(5) … I considered a problem as challenge	.779					
(6) … I made decisions, although I was not 100% sure.	.387		.456			
(7) … I actively avoided tasks/situations, because I felt overloaded.	.308				.626	
(8) … I searched for solutions to a problem together with my colleagues.	.671					
(9) … I worked on improving myself in my job.	.440					.447
(10) … I had sufficient knowledge to perform my tasks.		-.698				
(11) … I avoided any risk.					.707	
(12) … I relied on my intuition when faced with a difficult situation.			.813			
(13) … I achieved a good result by improvising.			.780			
(14) … I was sceptical in a new situation.		.401	.330		.396	
(15) … I knew who to attend to in case of problems.						.772
(16) … I adopted my way of working to the situation.						.581
(17) … I made use of informal contacts to solve a problem.		.564				.411
(18) … I actively avoided a situation that seemed chaotic to me.					.691	
(19) … I was not able to perform tasks as per procedure, because required resources were missing.		.755				
(20) … I was missing certain information to cope with a difficult situation.		.799				

Questions loading on one factor were clustered and underwent subsequent analysis of reliability. Eight Questions 6, 7, 10, 11 and 14-18 were excluded due to insufficient corrected item-total correlations <.35 and/or multiple factor loadings. The remaining 12 questions proposed for further use and validation are shaded in grey (Table 2).

Table 3 gives an overview of the four components extracted including Cronbach's Alpha values for internal consistency (reliability). Two of four components underlying organisational resilience (shaded in grey) demonstrated an acceptable level of Cronbach's Alpha = .70 according to Tabachnik & Fidell, (2007). The remaining two components just missed the cut-off point.

Table 3. Cronbach's alpha values for internal consistency (reliability) of the latent variable behaviour towards organizational resilience (N=282)

Component Name	Total item count	Item reference*	Cronbach's alpha
Goal-directed/ proactive solutions	5	3, 4, 5, 6, 8, 9	.787
Flexibility	2	1, 2	.633
Improvisation	2	12, 13	.671
Availability of Resources	3	19, 20	.708

*Note. Items 7, 10, 14-18 were excluded.

4 DISCUSSION

This paper adds significant value to empirical research and best practices within the Aviation industry by proving four components underlying behaviour towards organisational resilience as stable across three different occupational groups. Although two of four components just missed the .70 cut-off for internal consistency (Tabachnik & Fidell, 2007) it can be concluded that results confirm previous research (Table 1). One reason for the insufficient Cronbach's alpha values is the small number of items used to assess the associated two components. It is therefore recommended to include additional items based on the Inventory of resilient behaviour at the place of work (Kolodej et al., 2012) in a second validation. Previous work (Heese & Kallus, 2012) recommended excluding the component *flexibility* due to insufficient reliability. However, in view of Woods (2006) considering *flexibility* as one of the major resilience principles and in light of linking the behaviours to day to day operations, it was decided to keep *flexibility* as standalone the component.

Reason (2001) argued that human variability makes dynamic systems safe. Lessons from the Hudson (Pariès, 2011:15) identified "a very fast overall operational comprehension of the unexpected situation" going along with "a highly dynamic (re)planning capacity" and "some sense of improvising and adapting to the required emergency procedures" as behaviours supporting organisational resilience. Further, Pariès (2011) highlighted that controlling stress, as well as training and experience was a key factor contributing to the miracle of the Hudson. Woltjer et al. (2013) warned from prescribing normative behaviours towards organisational resilience claiming that depending on the situation/disturbance one behaviour maybe the right one, while in a different situation/disturbance it may be considered wrong. While this paper acknowledges this note of caution, there is a strong need from an organisational perspective to break down the resilience engineering concept to actual tangible behaviour that can be observed in every day operations. Executive managers want to know how to up-skill their staff to bounce back quickly after disturbances and handle unexpected situations. Recruiters and trainers want to know what skills to look for to create future heroes and finally operational staff wants to be reassured that their performance ensures safe and efficient operations.

Recent literature offers a broad range of theories and models focusing on engineering resilient systems (Hollnagel et al., 2011), but only little focus is placed on "engineering" the individual or teams. Understanding why things go right in every day operations and identifying which behaviours compensate for disturbances is therefore considered key to overcome vulnerabilities for competitive advantage.

5 OUTLOOK

Following the initial validation of I-BORA it was attempted to derive actual behaviours towards organisational resilience that can be observed on the job. Safety-related reconstruction interviews based on the integrated task analyses approach (Kallus, Barbarino & vanDamme, 1998) were used to find out how operational staff handles expected and unexpected situations. Table 4 presents a draft list of resilient behaviours linked to validated components including examples from the ATCO group to facilitate understanding of the reader.

Table 4. Draft behaviours towards organisational resilience in day-to-day aviation operations

Component	Resilience Principle (Woods, 2006; Woltjer et al., 2013)	Behaviour	Example from the air traffic control operations room
Goal-directed/ proactive solutions	Goal trade-offs	Trades conflicting goals (capacity/efficiency/cost)	ATCO proactively offering an earlier slot, direct routes/ taxiways
	Coordination	Anticipatory planning/coordination	ATCO caters for alternative options (plan B and C)
	Timing/Pacing/ Synchronisation	Takes conditions of colleague into account	ATCO waits until work step is completed before interrupting
Improvisation	Approximate adjustments	Bends standard operating procedures for safety/ efficiency/ capacity purposes (use best judgement)	ATCO hands-over aircraft earlier to the next sector
	Actual practice/ techniques	Invents work around procedure	ATCO referring to use cases for known system bugs
Flexibility	Buffering capacity, margins, tolerance	Actively increases safety buffers (defensive controlling)	ATCO providing additional separation for inexperienced pilots
	Adaptive capacity	Takes on a colleagues' s responsibility temporarily	ATCO covering for 2nd position temporarily
Availability of Resources	Complexity/ Procedures	Consults written/printed documentation (manuals, procedures)	ATCO referring to route charts for alternative waypoints
	Underspecification	Looks up electronic/ information online	ATCO consults current AIP online

In addition operational staff was asked to rate the previous shift using a 50-point Subjective Critical Situations (SCS) rating scale (Kallus, Hoffmann & Winkler, 2008) from 0=routine situation to 50=critical incident as well as assessing Taskload, Efficiency and Safety Buffers (TEST) (Kallus, Hoffmann, Winkler & Vormayr, 2010). Interview and behavioural data are still subject to analysis and will be reported and interpreted in context with the data from the rating tools.
In view that controlling stress was identified to be a key factor in handling unexpected situations (Pariès, 2011) results will finally be validated in the simulator investigating whether behaviour towards organisational resilience remains stable under stressful versus non-stressful conditions.

In conclusion this paper provides a wide range of methods and tools to be used to assess behaviour towards organisational resilience in aviation hoping to have contributed to making the new resilience engineering approach more tangible and relevant for organisations and staff.

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