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Development of a methodology for understanding and enhancing safety culture in Air Traffic Management

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ABSTRACT

There is increasing interest in applying the concept of safety culture in Air Traffic Management (ATM). Using a mixed methods approach, this paper describes the development of a safety culture management toolkit that uses questionnaires and safety culture feedback workshops. The development process involved four phases. Phase 1 involved a review of the safety culture literature from 2001 to 2005 to identify relevant safety culture themes. Phase 2 involved conducting interviews with personnel ($n = 52$) from four geographically disparate European Air Navigation Service Providers (ANSPs) to validate and identify themes relevant to ATM. Follow-up focus groups ($n = 3$) consolidated the themes, and developed a preliminary set of questionnaire items; Phase 3 involved piloting a safety culture survey instrument with ATM staff ($n = 537$) in four countries. Construct validity of the questionnaire was tested using both Exploratory and Confirmatory factor analysis (EFA, CFA). Substantial refinement of the item set was required to establish a consistent model, and a second sample ($n = 883$) was surveyed to replicate the model. Phase 4 involved conducting feedback workshops with ANSP personnel in study locations ($n = 7$) in order to further validate the themes identified in the questionnaire. These were used to develop qualitative insights (e.g. specific safety problems and solutions) relating to the results of the questionnaire at each ANSP. The study aimed to develop a bespoke quantitative measurement instrument (and qualitative feedback tool) with construct and discriminant validity, and the ability to consistently measure safety culture in ANSPs throughout Europe, and facilitate safety improvements in air traffic management. This aim was partially achieved, and although the safety culture toolkit was perceived as useful for exploring and highlighting safety issues at a local ANSP level, further work is required. This will involve developing the tool to ensure it operates consistently in different national and cultural setting, and designing metrics for testing the criterion validity of the safety culture toolkit.

1. Introduction

Air Traffic Management (ATM) is considered to be a 'high reliability' industry and accidents are rare. However recent accidents have contributed to an increased focus on measuring and managing safety culture. For example, 114 passengers, crew and ground staff died in the 2001 Linate collision between a MD-87 and a Cessna 525-A taxiing on the runway. Furthermore, 71 passengers and crew died in the 2002 Überlingen mid-air collision between a Boeing 757-200 and a Tupolev TU164M. To cope with infrastructure failures in key systems and insufficient manpower, air traffic controllers were forced to take shortcuts and violate procedures, resulting in operational safety being compromised (Johnson and Shea, 2007). This resonates with safety culture, a concept that has its roots in the organisational culture and anthropological literature (Guldenmund, 2000), and emerges from the notion that organisational values, norms, activities, management, and history shape employee' behaviours (Schein, 2004). Safety culture represents employee' attitudes about an organisation's approach to safety, their perceptions of risk, their beliefs on responding to and controlling risk, and engagement in activities that represent (and reinforce) safety culture (Glendon et al., 2006; Pidgeon, 1998). It has been shown to predict safety performance in industries including nuclear, chemical, offshore and rail (see Clarke, 2006; Christian et al., 2009, for meta-analyses).

For many years, and particularly since the Uberlingen accident, European ATM has been developing and implementing safety management systems. The past decade saw the implementation of a number of 'ESARRs' (EUROCONTROL Safety and Regulatory Requirements) to European Air Navigation Service Providers (ANSPs). These involved ensuring ANSPs had a safety management system (SMS), near-miss reporting systems, and safety assessments of changes. Such approaches and legislation has been instrumental in ensuring that ANSPs have the competence, processes and systems

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to ensure an appropriate focus on operational safety is maintained, and the likelihood of mishaps reduced (e.g. see Perrin et al., 2007).

ATM differs from a number of 'high-risk' industries such as nuclear power, chemical and petrochemical industries in that the air traffic controllers (ATCOs) are in direct, real-time control of aircraft. There are few engineered safeguards, and no 'emergency shutdown' or 'stop' function. The ATCOs are therefore truly at the front line of safety, and follow procedures and have extensive training. Yet, procedures are guidelines and each ATCO may face a unique situation every day depending on the traffic and weather pattern. Critical situations evolve under relatively short timeframes, e.g. under 3 min (Kirwan, 2011). Therefore, while certain other industries may be able to monitor and 'control' or assure safety via audits and safety cases, ATM safety has an immediacy that warrants a method focusing on the ATCOs themselves and their working practices. Audits can elicit 'angel performance' – whereby behaviour is changed due to the presence of an auditor, and then returns to 'normal' afterwards. Although observational safety studies can observe performance anonymously (usually by specially trained controllers) to overcome this problem (Eurocontrol, 2011), safety culture assessment may be useful for identifying vulnerabilities that are recognised by staff but not mentioned in a formal environment or audit (e.g. due to a poor reporting culture).

The awareness, understanding and motivation of ATM employees (e.g. air traffic controllers) to engage in safety-related activities (e.g. raising safety concerns about technical systems) is seen as particularly important for maintaining safety. Engagement is likely shaped by attitudes and beliefs relating to safety culture, and research in the ATM sector has begun to show the relevance of applying the safety culture concept (Ek et al., 2007; Gordon et al., 2006). This has resulted in a EUROCONTROL project called "Understanding Safety Culture", which we report on. It develops and tests a methodology tailored for measuring, understanding, and providing guidance on safety culture concepts for a sample of European ANSPs. It draws on both the safety culture and safety climate literatures, and aims to avoid future accidents through measuring safety culture, identifying system vulnerabilities, and initiating change.

1.1. Safety culture and safety climate

The concept of safety culture emerged in the late 1980s after the Chernobyl disaster, and broadly refers to how organisational management and human factors shape safety outcomes (Flin et al., 2000). Focussing on workplace attitudes and activities relating to safety, numerous factors underlie safety culture development and maintenance. These include communication (explicit and tacit) on safety within an organisation, incident reporting systems, apportionment of blame, managing and learning from incidents, investment in safety systems, emergency management procedures, and training and awareness of human factors (e.g. teamwork, effect of stress and fatigue on performance) (Reason, 1997). The multifaceted nature of safety culture means that there is a lack of consensus about how exactly it is defined, measured and managed (DeJoy, 2005; Guldenmund, 2007). The related, but more tightly defined, concept of safety climate focuses primarily on employee attitudes (usually at group level) towards safety.

Safety climate refers to how employees perceive the enactment of organisational policies and procedures relating to safety in their organisation at a given point in time. It is closely aligned with the organisational climate literature, and focuses upon employee' perceptions on the extent to which safety is an organisational priority in relation to other organisational goals, for example production or efficiency (Griffin and Neal, 2000; Neal and Griffin, 2006; Zohar and Luria, 2003). These perceptions influence risk-taking and safety-related behaviours (Zohar, 2010), with management and group-level factors mediating the relationship (Zohar, 2002, 2003). Employees are informed about the possible consequences of safe or unsafe behaviours through explicit and implicit statements and actions by managers and co-workers regarding safety, and messages from management on the relative importance of safety. Safety climate differs from safety culture as it does not cover individual attitudes or affective reactions towards specific safety issues, individual ratings of risk, normative beliefs about safety, perceptions of individual knowledge, or self-reports of safety behaviour (e.g. compliance with rules or involvement in safety activities). Griffin and Neal (2000) argue that whilst these may be related to safety climate as antecedents or mediators, safety climate perceptions are conceptually distinct from safety attitudes and safety behaviours. From the perspective of the current study, ATM staff perceptions of safety climate are relevant, as perceptions on management prioritisation of safety are likely to shape a range of behaviours (e.g. risk-taking behaviours, reporting safety problems and near misses). However, concepts more typically associated with safety culture research also appear important.

Safety culture is arguably less theoretically developed than safety climate, and refers to a wider range of constructs. Building on the organisational culture literature, Reason (1997) suggested five important components of safety culture: (i) informed culture, (ii) reporting culture, (iii) just culture, (iv) flexible culture, and (v) learning culture. An 'informed culture' is where data from accidents and near misses are collated and combined with data from safety audits and climate surveys (Grote and Kunzler, 2000). For this to occur a 'reporting culture', whereby the workforce engage in near miss reporting, safety surveys and safety initiatives, is required. Trust in the fairness and results of safety systems is essential ('just culture'), but this is distinct from a no-blame culture (i.e. criminal or negligible acts are still punished). To utilise safety data there must be flexibility to respond in novel ways to system or environmental perturbations or threats (a 'flexible culture'), and a 'learning culture' is needed to draw appropriate conclusions and implement necessary changes (e.g. to procedures). A learning culture is especially important in an industry like ATM where there are very few accidents. In other industries where there are frequent fatalities, and such statistics are available, the lessons are clear and the motivation to do better is a case easily made. However, in an industry where accidents occur every ten years or billion flight hours (effectively the European safety rate), the need to maintain stringent safety standards in an economically depressed business environment is less obvious. As Weick (1987) noted, high reliability organisations stay so by being proactive and paying attention to weak signals, and in the case of ATM, this means looking closely at the near-events which occur, to see what can be learned from them, and for preventing future incidents.

These components are similar to those cited by Weick (1987), whose criteria for high reliability in an organisation is a culture that encourages interpretation, improvisation, unique action, and a climate of trust and openness between management and workers. A set of social norms emerge whereby positive and clear behavioural rules relating to safety are established (Edmondson, 1999; Ostram et al., 1993). This is particularly important for organisational learning on safety, with change occurring at a local level to meet on-the-ground needs (Naevestad, 2009). The safety culture components described by Reason (1997) appear especially important for understanding how employees and management in ATMs respond to and manage safety related-data. Near-miss reporting and effective workload management are critical to managing safety, and staff reporting is the primary source of data for understanding threats to ATM safety. Thus, developing a safety culture which encourages reporting and facilitates learning is essential.