after the storm had hit, there were more aircraft on the tarmac than could be assigned to gates. Gridlock ensued. Passengers could not deplane. Passengers in the terminal could not depart. The airline has calculated the economic costs it incurred but has no way of knowing the goodwill it lost.

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Human Factors and Aerospace Safety 1(4), 381-385

CRITICAL INCIDENTS

Follow the procedure or survive

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A large passenger aircraft flies near Halifax, Nova Scotia. It is 1998. After an uneventful departure, a burning smell is detected and, not much later, smoke is reported inside the cockpit. The cockpit crew consists of two pilots. According to Carley (1999), the co-pilot wants a rapid descent, and suggests dumping fuel early so that the aircraft will not be too heavy to land. But the captain tells the co-pilot, who is flying the plane, not to descend too fast. The captain insists they cover the applicable procedures (checklists) for dealing with smoke and fire. The captain delays a decision on dumping fuel. With the fire developing, the aircraft becomes uncontrollable and crashes into the sea, taking all 229 lives onboard with it.

There is a persistent notion in aviation that not following procedures can lead to unsafe situations and outcomes. For example, a study carried out for an aircraft manufacturer identified 'pilot deviation from basic operational procedure' to be a primary factor in almost 100 accidents (Lautman and Gallimore, 1987; p. 2). In the wake of failure it can be tempting for managers to introduce new procedures or change existing ones, or enforce stricter compliance – all to ensure that similar failures will never happen again. For example, shortly after a fatal shootdown of two U.S. Black Hawk helicopters over Northern Iraq by U.S. fighter jets, 'higher headquarters in Europe dispatched a sweeping set of rules in documents several inches thick to 'absolutely guarantee' that whatever caused this tragedy would never happen again' (Snook, 2000, p. 201). It seems there is a model about procedures and safety that assumes that procedure application is simple rote rule following. It rests on the following premises:

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- Procedures represent the best thought-out, and thus the safest way to carry out a job.
- Procedure-following is mostly simple IF-THEN rule-based mental activity: IF this situation occurs, THEN this algorithm applies.
- Safety results from people following procedures.
- For progress on safety, organisations must invest in people's knowledge of procedures and ensure that they are followed carefully.

To be sure, procedures and standardisation play an important role in shaping safe practice. But there is ambiguity. First, there is ample evidence that a mismatch between procedures and practice is not unique to accident sequences (Woods et al., 1994; Snook, 2000). In other words, not following procedures does not necessarily lead to trouble, and safe outcomes in aviation and elsewhere may be preceded by just as (relatively) many procedural deviations as accidents are. (This renders Lautman and Gallimore's cases, selected on the dependent variable, entirely uninformative.) Second, data from aircraft line maintenance consistently shows that it is routinely impossible to follow the rules and get the job done at the same time (Van Avermaete and Hakkeling-Mesland, 2001). Third, some of the safest complex, dynamic aviation systems in operation today do not really have procedures written down for some of their most challenging activities. Rochlin, La Porte and Roberts (1987, p. 79), commenting on the introduction of ever heavier and capable aircraft onto naval aircraft carriers, note that 'there were no books on the integration of this new hardware into existing routines and no other place to practice it but at sea...Moreover, *little of the process was written down, so that the ship in operation is the only reliable manual*' (emphasis added). Jobs are 'neither standardized across ships nor, in fact, written down systematically and formally anywhere'. Yet naval aircraft carriers – especially given their inherently high-risk environment and operations–have a remarkable safety record, like other so-called high reliability organisations (Rochlin et al., 1987; Rochlin 1999). This, then, is the tension. Procedures are an investment in safety, but apparently not a necessary and certainly not a sufficient one. Procedures spell out how to do the job safely, yet following all the procedures can lead to an inability to get the job done in the first place.

Operational people must interpret procedures with respect to a collection of actions and circumstances that the procedures themselves can never fully specify. In other words, procedures are not the job. Circumstances change, or are not as was foreseen by those who designed the procedures. Safety, then, is not the result of rote rule following; it is the result of people's insight into the features of situations that demand certain actions (e.g. Klein, 1993; Sanne, 1999). This leads to a second model with respect to procedures and safety. Model two says that:

- Procedures are resources for action. Procedures do not specify all circumstances to which they apply. Procedures cannot dictate their own application. Procedures can, in themselves, not guarantee safety.

- Applying procedures successfully across situations can be a substantive and skilful cognitive activity.
- Safety results from people being skilful at judging when and how (and when not) to adapt procedures to local circumstances.
- For progress on safety, organisations must monitor and understand the reasons behind the gap between procedures and practice. Additionally, organisations must develop ways that support people's skill at judging when and how to adapt.

The potential for surprise, against the background of multiple goals and pressures, exists in every complex, dynamic operating world. And consequently, the problem that surrounds the application of procedures does. Pre-specified guidance is often not prepared to deal with situations that present considerable novelty or uncertainty. In both trying their best to deal with the situation, the pilots of the aircraft mentioned above are painted by Carley (1999) as respective embodiments of the two models on procedures and safety. The captain follows model one, the co-pilot prefers model two. The case presents a fundamental double bind:

- If rote rule following persists in the face of cues that suggests procedures should be adapted, this may lead to unsafe outcomes. People can get blamed for their inflexibility; their application of rules without sensitivity to context.
- If adaptations to unanticipated conditions are attempted without complete knowledge of circumstance or certainty of outcome, unsafe results may occur too. In this case, people get blamed for their deviations; their non-adherence.

In other words, people can either fail to adapt, or attempt adaptations that may fail. Near Halifax, outcome was the final arbiter: it ruled that failing to adapt was inappropriate given the rapidly deteriorating situation. Circumstances made rote rule following a de-synchronised and increasingly irrelevant activity; de-coupled from how events and breakdowns were really unfolding and multiplying throughout the aircraft. Yet attempted adaptations were surrounded by uncertainty too–uncertainty about the very need for adaptations (how badly ailing was the aircraft, really?) as well as uncertainty about the effect and safety of adapting: How much weight would be permissible for a landing? How fast could the crew descend and still make a landing within the confines of the runway at Halifax? Such attempted adaptations, and the ability to project their potential for success, were not necessarily supported by specific training or overall professional indoctrination. Civil aviation, after all, tends to emphasise model one: stick with procedures and you will most likely be safe (e.g. Lautman and Gallimore, 1987).

Merely stressing the importance of following procedures can increase the number of cases in which people fail to adapt in the face of surprise. Letting people adapt without adequate skill or preparation, on the other hand, can increase the number of failed adaptations. One way out of the double bind is to develop people's skill at adapting. This means giving them the ability to balance the risks

between the two possible types of failure: failing to adapt or attempting adaptations that may fail. It requires the development of judgement about local conditions and the opportunities and risks they present, as well as an awareness of larger goals and constraints that operate on the situation. Development of this skill could be construed, to paraphrase Rochlin, as *planning for surprise*. Indeed, as Rochlin (1999, p. 1549) has observed: the culture of safety in high reliability organisations anticipate and plan for possible failures in 'the continuing expectation of future surprise', something that has been re-emphasised in Woods and Shattuck, 2000, and alluded to in Westrum, 1993, while Weick argued in 1988 that such capacity (for example as contained in people's skills) can critically affect people's ability to manage crises. The question of how to plan for surprise – how to help people develop skill at adapting successfully – however, remains elusive: 'The issue of the specificity with which emergence procedures following should be trained is one for which more research is clearly needed' (Messick-Huey and Wickens, 2000, p. 210). While some novel insights are being produced (e.g. Woods and Patterson, 2000) more research in this area is critically necessary.

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