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A pragmatic mapping of factors behind deviating acts in aircraft maintenance

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ABSTRACT

In this paper, we analyze twelve cases of deviations from prescribed procedures during scheduled/unscheduled maintenance checks, carried out by an aircraft maintenance organization in Greece. The detailed analysis of these cases let us identify specific factors that guided maintenance technicians towards alternative courses of action. Our focus is not on the material etiology of deviations but on the underlying factors that determined the actual decision action path by the air maintenance technicians. A generalization of factors is then being made, out of the specific factors identified for each case.

The factors identified ranged from the most normative (e.g. manuals) to the most contextual ones (e.g. personal comfort, schedule pressures). We suggest that by making generalizations of specific factors identified from a pool of specific cases, we gain intimate knowledge on the cognitive and organizational basis of deviations. The intimate knowledge of the etiology of deviations may help us advance towards a resilient safety management in aircraft maintenance; one that goes beyond the striving for compliance, a safety management that (i) acknowledges people on the shop floor inevitably make choices and (ii) supports them in taking more "informed" and accountable decisions.

1. Introduction

Maintenance constitutes one of the largest costs facing airlines. It has been estimated that for every hour of flight, twelve man-hours of maintenance are spent [1]. Maintenance-related failures have been associated with up to 15% of major aircraft accidents [2]. Despite this seemingly small percentage, Allen and Marx [3] found that maintenance related failures are the second leading cause of fatal accidents in aviation, exceeded only by pilot error. Since 1962, the percentage of maintenance-related accidents has remained close to constant, although their severity seems to increase [4]. In 2003, Flight International reported that 'technical/maintenance failure' emerged as the leading cause of airline accidents and fatalities, surpassing controlled flight into terrain, which had previously been the predominant cause of airline accidents. According to former National Transportation Safety Board member John Goglia, deficient maintenance has been implicated in 7 (out of 14) recent airline accidents [1]. Maintenance related failures not only pose a threat to flight safety, but can also impose significant financial costs through delays, cancellations, diversions, and other schedule disruptions. Maintenance activities mostly associated with accidents include installation processes, modifications, inspections and adjustments [1].

Recent literature in aircraft maintenance safety tends to accept that deviations, uncertainties and surprises are inherent and to a large extent inevitable in maintenance operations [5,6]. Moreover, reporting on errors and mistakes has always been problematic within aircraft maintenance [5]. Years of focusing on human error resulted on information campaigns highlighting accidents and telling people not to commit errors again. For maintenance organizations it has been empirically proven that focusing on errors is insufficient for successful safety management [5,7]. Both studies on the assessment of risk and on its management tend to focus less on errors and turn to the analysis of contextual and organizational factors as well as to their complex interrelations as sources of both poor and successful performance. For example, Mohaghegh et al. [6] propose to extend the Probabilistic Risk Assessment (PRA) modeling frameworks to include the effects of organizational factors. Their top-down, model-based approach includes networks of generic organizational factors (i.e. safety culture, financial stress etc.) as the deeper, more fundamental causes of accidents and incidents. Contemporary risk management research also tends to focus more on the subtleties of day-to-day performance, and on their organizational precursors than on error prevention. For example, Ward et al. [5], developed and tested a

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bottom-up participatory identification and reporting system during aircraft maintenance checks that is not based on incidents, failures or errors, but on what the authors term 'blockers' to task performance. A performance report, the blocker report, specific to aircraft maintenance and related to the model was developed gathering data on anything that 'blocks' task or check performance (i.e. tools/equipment/parts/materials, team set-up/lack of coordination, time pressure/stress/knowledge/skills/motivation/fatigue, workplace temperature/access/air/noise/lighting etc.). Contrary to errors or incidents, blocker reporting and resolution process focuses on the management and resolution not of human performance per se, but of work environment factors that may negatively affect this performance.

In the present paper, we report on the analysis of twelve cases of deviations from formal procedures during aircraft maintenance checks. Specifically, we identify sets of specific contextually bound factors (e.g. blockers ibid) that influenced in each case the technicians' decision–action paths. These factors are subsequently mapped in as networks that progressively press technicians' decisions towards deviations. Out of the specific factors identified for each case a categorization is made iteratively, based on Grounded Theory principles. This process resulted in five generic factors, which are claimed to be endogenous of the particular work system. The term generic was chosen to signify that these factors are claimed to be persistent and recurring for the particular work system.

The aim of the above analysis is not to identify specific factors, since these are transient and contingent to each particular case; the aim is to advance our understanding of the underlying organizational and cognitive dynamics behind deviating acts, i.e. how much subjectivity or arbitrariness is there behind the choices being made by technicians or how much and through which channels do the externally induced contingencies each time constrain the possible choices. A deeper understanding of the nature of technicians' decision–action paths is critical for the improvement or revision of risk management methods in aircraft maintenance as well as in other safety critical industries. The remainder of the paper is structured as follows: first the theoretical background of the research is presented. Second the research method that was followed in order to identify the cases of deviating acts is presented. Next follows the analysis of the twelve cases identified, along with a detailed description of four of them for illustration purposes. After the analysis of the individual cases, the generic factor analysis is presented. Finally, the paper ends with the discussion on the eventual application of the method in industrial settings and also on the steps forward in the research.

2. Theoretical background

Organizing work in general, is based on axioms of predictability and formalization, where work as performed would ideally be a realization of work as imagined [8].

Towards this direction, various levels or prescription (e.g. procedures, work-methods, task-cards) are introduced in work settings by various supervising entities, to define what needs to be done and how it should be done. Nevertheless, organizing through top-down prescriptions does not imply that people working within a work setting will simply follow what is predefined, in order to accomplish certain tasks. Workers often face ambiguity in their day-to-day conduct and often find themselves in the midst of dilemmas. To resolve dilemmas, workers have to judge, decide and develop certain modes of action. Actual work practice will then often deviate from what is prescribed [9].

The traditional way to tackle discrepancies between practice and prescription is by the concept of conformance through control of deviation or amendments to prescriptions. Such a strategy, although intuitive and easy to understand and apply, is not sufficient beyond a certain level of systematization. As Perrow [10] has demonstrated almost thirty years ago, organizational oversize leads to interactive complexity and over systematization to tight coupling; the result is unpredictability. In the face of unpredictability the above strategy ultimately tends towards a vicious cycle of more prescription resulting in more deviations and vice versa.

In this line of thought, it has been suggested that organizations should provoke a constant dialectic between what is prescribed and what is actually being done [11]. In other words, in order to enhance organizational resilience, one needs to acknowledge the mute confrontation between what is actually experienced – i.e. work as practiced – and what is prescribed. By accepting and uncovering this confrontation (i.e. through a dialectic process), an organization may ultimately gain in ability to absorb diverse threats and adapt accordingly.

Expanding the above, it is suggested that a combination of context related and organizational factors often drive or even impose workers towards certain decisions in order to make ends meet [12,13]; these decisions in turn will often lead to actions at the edge of compliance or to clear deviations from prescribed procedures. Such actions may indeed lead to unwanted consequences but they may also prevent unwanted effects from occurring. Therefore, the criterion for qualifying actions as adequate or not should not be confined to their possible deviation from prescribed procedures; it should also encompass the local performance conditions and other influencing factors that largely determine the workers' concrete activity.

This preoccupation with the details of everyday activity is in line with the emerging field of Resilience Engineering [14]. Resilience Engineering does not primarily focus on what went or on what can go wrong, but on how, pragmatically, things almost always go right even in marginal conditions or even in outside of the classic safety envelope.

3. Research method

Field observations were carried out, based on the ethnographic approach, in order to identify deviating acts during maintenance checks and to analyze the determining factors behind these deviations. One researcher carried out field work, including systematic observations and interviews with the aircraft maintenance technicians (AMT). The field work lasted in total twelve days, five hours per day. An extensive familiarization period of one year preceded actual fieldwork period including apprenticeship periods to all the departments of the organization in order to become as native as possible to the work domain.

The AMT group performing the scheduled and unscheduled checks was a team of mechanics and avionics technicians. Each member was appointed to a certain role namely team leader, authorized technician and assistant technician. The majority of team members had worked jointly under the supervision of the maintenance organization for the past 3 years in equivalent maintenance teams. The experience of the team members ranged from 6 months to 25 years.

During observations, the researcher was closely following and observing the actions of one of the AMTs per task, checking the task instruction being carried out. Hence, only a proportion of the total actual maintenance actions that were carried out at the hangar were observed. The observations were enough, though, to identify a number of deviating acts. AMTs were probed to verbalize, justify and discuss their actions in terms of what, why and how. The researcher tried not to distract the technicians